Assessment of the Conditions of Medium-size Shipbuilding Company to Build Offshore Structures

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ABSTRACT

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By **Nguyen Thua Duong**

In recent decades, the competition in worldwide shipbuilding sector has become extremely tough and intense due to two main reasons:

The first reason can be seen is the financial and economic crisis going along with reduction of oil price affect effectively the world’s shipbuilding industry. This causes the most painful impact on many shipbuilding countries over the world by the biggest overcapacity of shipyards ever seen and far greater supply of fleet than required by the global market.

The following reason is the overall EU shipbuilding situation has changed significantly. Global competition has been increasing, especially from Asia, where low labour cost countries have taken over building of more and more standard type of ships and manufacturing of many different and more complex components for offshore structure.

As result, many shipyards have been disappeared or forced to make a series of structural changes which have resulted in lower employment for its survivability.

Another solution is the EU shipbuilding has managed to maintain a strong position in highly specialized and qualitatively outstanding products. The EU shipbuilding industry is well- known for its ability to develop and deliver new cutting - edge solutions and innovative production processes to existing and new markets.

By analyzing the practical condition in specific existing medium-sized shipyard, we can assess the productivity and survivability of this type of company. The report has been conducted by going through various factors that can help us to clear define the advantages and disadvantages of company after that finds the solutions to enhance their strength and also minimize these drawbacks.

The evaluation of these factors determining competitiveness of shipyard is taken by the productivity, production range, and attractiveness of product, subsidy rate, exchange rate and cost position.

The report specifies the possibility for construction not only for shipyard but also the feasibility of some designs which are not always satisfied and impossible for practical work. This is noticed that production work can modify the design drawing based on their long term experience so as to have benefit to both shipyard and their clients.

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Declaration of Authorship

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Where I have consulted the published work of others, this is always clearly attributed.

Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.

I have acknowledged all main sources of help.

Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma.

I cede copyright of the thesis in favour of the University of West Pomeranian University of Technology.

Date: January 10, 2016 Signature

1. INTRODUCTION

1.1. Overview of shipbuilding industry

Shipbuilding is known as one of the oldest, most open and highly competitive markets in the world. Although shipbuilding industry has a long time experience in how to survive with fluctuation of economy, the current global crisis hit shipbuilding industry rather severely.
The global maritime sector copes up with additional obstacle from a significant excess capacity, especially due to the rapid improvements in the productivity of the shipyards and the over-investments in this field.
The increasing production capacity, typically in several Asian countries, was expanded forcefully before the economic crisis in only short time of period, for instance, China quickly became the largest shipbuilding nation in the world. Europe, conversely, has lost its market share for the booming maritime industries in the Far Eastern countries, particularly China and South Korea, which are producing series of standardized vessels at low costs.
However, the most competitive strength of the European clusters bases on high quality and specialization, it is possible to remain their market share particularly in some special types of products, such as cruise ships and working ship and offshore structures . The imbalance between supply and demand in shipbuilding has also affected global markets because of large amount of new tonnage entering the market. Although the demand for shipping services has been growing after the economic went down, the fleet oversupply is still overrunning the cargo growth and the future demand for cargo ships is still uncertain.

1.2. Goal and problem formulation

The aim of this thesis is to explore the potential of medium-sized shipyards as one of solution for shipbuilding industry in the context of the European markets.
In the effort to analyse potential problems within the formulation, two major aspects have been focused on:
1) What is the full potential of medium-sized shipbuilding company in the European and global markets by investigating various factors that affect efficiency of construction and also profit for company?
2) What are the recommendations to improve the competitiveness of this company?

1.3. Method

In order to fulfil the goal of this study, qualitative method was used and a great care was taken by using only approved literature from leading experts in relevant fields and practical work documents in real construction period.

Academic books, previous research reports, articles and other relevant literature have been studied associating with production drawings, documents and pictures.

The purpose of comparing between literature knowledge and practical work was to know the discrepancy in real condition that task requirements are not able to satisfy in some circumstances.

2. CONSTRAINTS FOR SHIPBUILDING

2.1. Business challenges

2.1.1. The global market place of shipbuilding

The shipbuilding industry is marked by its global presence, with ships being built in industrialized countries such as Japan, Europe, South Korea and China. The geographical distribution of new ship construction has shown significant changes starting from the original dominance of Europe to an increased position for Asian countries such as South Korea, Japan and China. At the demand side purchases are still dominated by European buyers in many segments.

The shipbuilding industry is affected mainly by two factor groups:

- macro factors (world seaborne trade, oil prices, economic stability, and political stability)
- market factors (subsidies by the government, scrapping of old vessels, charter rates, vessels on order).

Until the middle of the last century, the market of shipbuilding was dominated by Europe, having a world market share (in CGT) of over 80% at the beginning of the twentieth century. In the 1950s the position of Europe was being challenged by Japan, to be gradually taken over in the 70s, mainly due to fast growth of the Japanese economy and successful coordination of supporting program for shipbuilding as a strategic industry as well as various drawbacks in Europe, including the decrease of the European shipping fleet, lack of investment, poor labour relations and an inability to increase productivity levels, which helped Japan to win leadership.

At the early 1970s Japan and Europe together still dominated the world market with a combined share of some 90% (in CGT deliveries). [2]

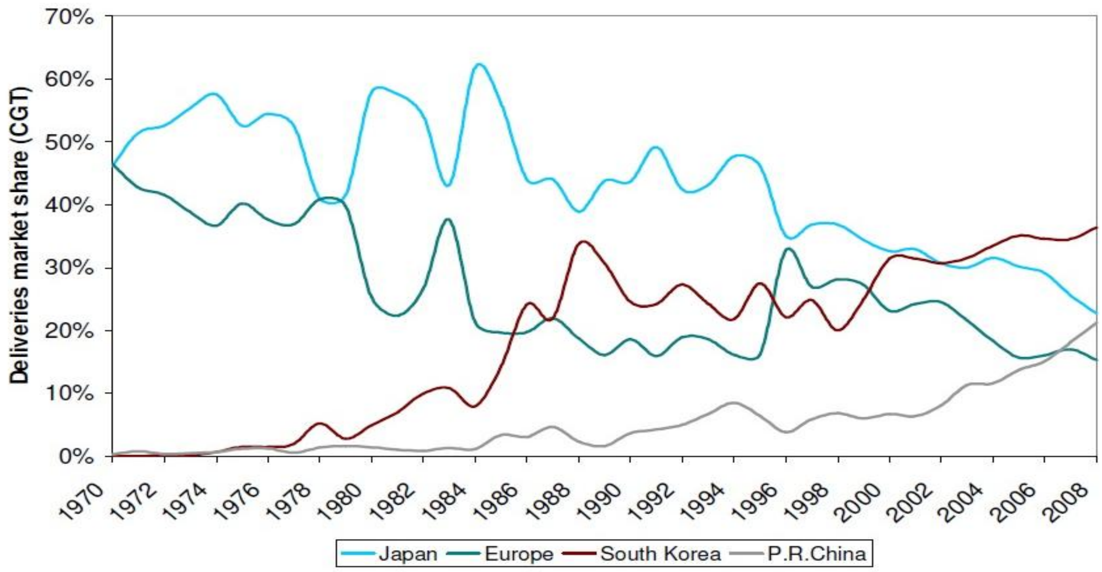


Figure 2.1 Market shares based on CGT form 1970 to 2008. [2]

In the early 70s the position of Japan was in turn challenged by South Korea as labour costs were rising in Japan, while South Korea combined low labour costs with a choice to position shipbuilding as a strategic industry for the country. In the mid-1990s the share of South Korea had increased to 25% and by 2005 it had overtaken the position of Japan measured in CGT deliveries.

The latest challenger on the international market is China, caught the industrial expansion strategy and surpassed Japan in 2006 and S. Korea in 2009 by order book volumes. The share of China has risen rapidly to over 20% of global ship deliveries in 2008 (in CGT). In terms of orderbook, China surpassed Japan in 2006 as the second largest shipbuilding region.

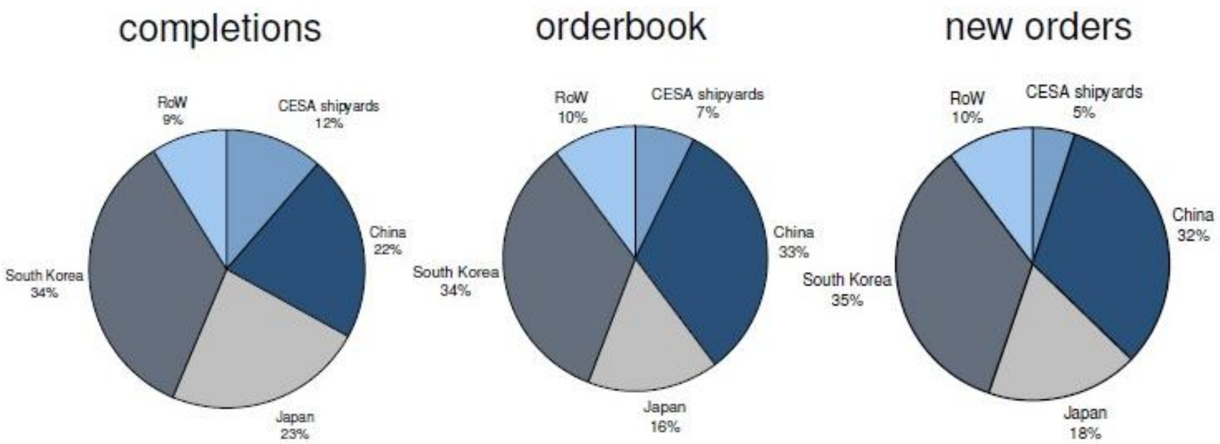


Figure 2.2 Market shares by completions, orderbook and new orders in 2008 in CGT. [2]

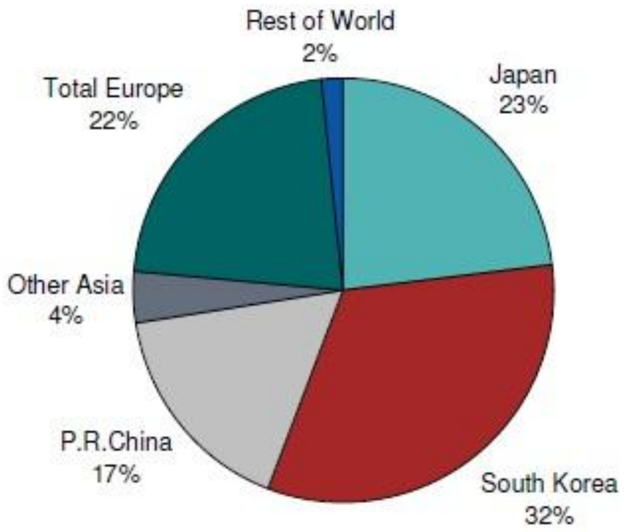


Figure 2.3 World market shares of production-value by region in 2007. [2]

Already new countries are emerging as potential shipbuilding nations, such as Vietnam, India, the Philippines and Brazil grew up and together reached the quantity of orders to equal European total. Europe has gradually been losing its positions in shipbuilding despite of its strategic specialization as a niche player. Unfair competition on the part of Asian shipyards and delayed agreements in global playing field have distorted the market, shifted it to the Far East and created extra problems fighting against crisis. The growth in the orderbook of these countries, which shows the strong acceleration in these countries in 2006 and 2007.

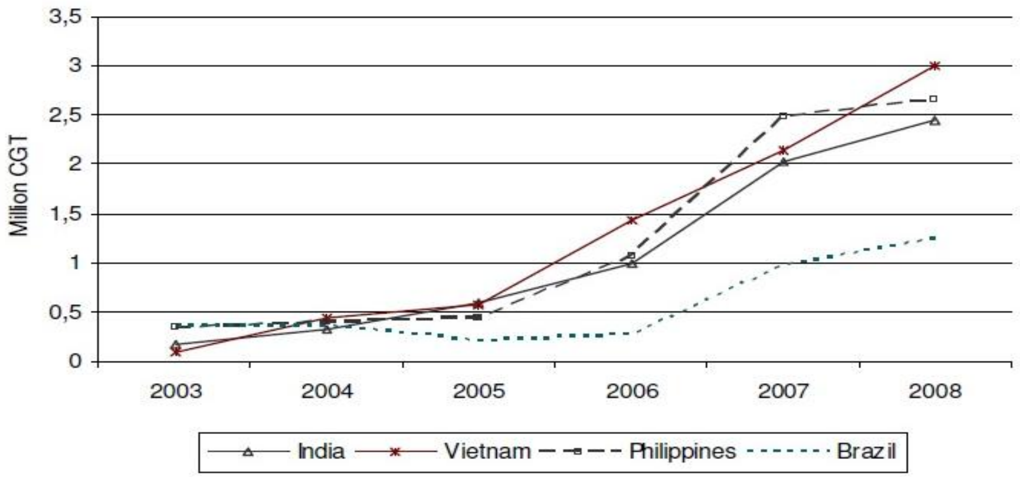


Figure 2.4 Orderbook 2003-2008 Main emerging markets. [3]

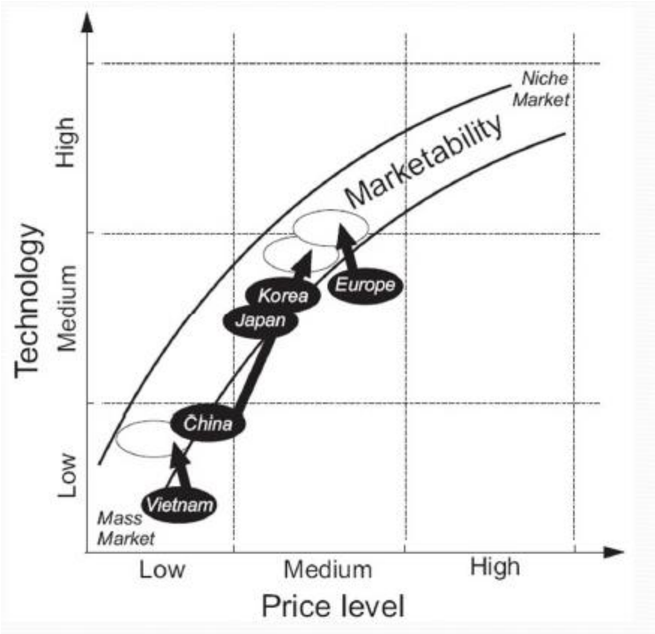


Figure 2.5 Worldwide economical context. [12]

Ordering new ships today is not reasonable, consequently, financing delivered ships is not to be preferable. Because the recovery of seaborne trade a is not able to supply enough shipping contracts to those suffering from the lack of cargo fleet. It is likely that some older ships will be dismantled; some inefficient ones should be renovated or converted. The visible fact is the world does not require as big shipyard capacity as is has today. Figure illustrates shipbuilding overcapacity surveyed in China, S. Korea, Japan, some new player countries, and Europe mainly. A huge reduction of 40-50% is estimated for existing capacity in the next 10 years.

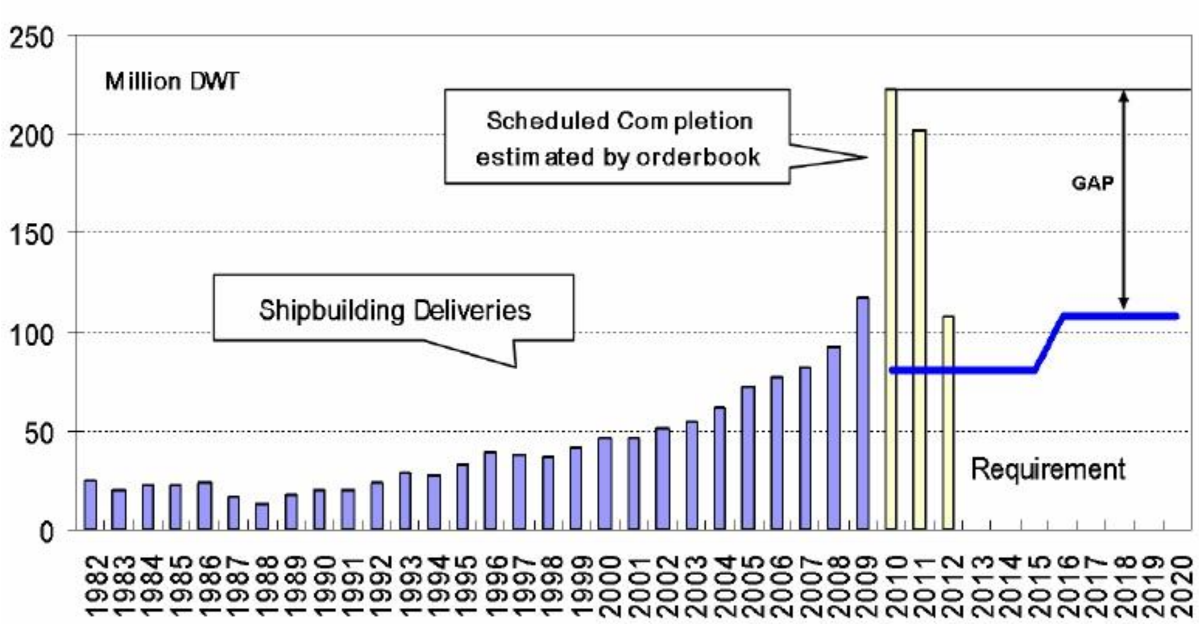


Figure 2.6 Shipbuilding overcapacity in some main shipbuilders. [3]

Table 2.1 Leadership in the global shipbuilding. [3]

Duration of the leadership	Country	Stage of business cycle	Causes
1860's – 1950's	Great Britain	Lost leadership	Failure to modernize shipbuilding industry
mid1950's – mid1990's	Japan	Post-maturity, weakening of competitive power	Ageing and high cost human resources. Reduced by shipyards R&D budget to less than 1%. The gap between the demand and supply for steel, increased prices of steel.
From mid 1990's	S. Korea	Post-growth, maintenance of competitive power	High cost human resources. The gap between steel demand and domestic supply increased steel prices. The appreciation of Korean Won has worsened the competitiveness of Korean shipbuilding.
Since 2010, earlier than it was planned	China	Acceleration of growth	The lowest labour cost. Ambitious State programmes for the development, growing shipyards capacity, governmental subsidies.

2.1.2. European shipbuilding

Figure 2.7 Overall view of European shipbuilding industry across countries. [3]

There is positive image with improvement in most countries and remaining situation in Germany, the biggest shipbuilding industry in Europe. There is only Croatia having negative picture.

Germany and Italy are traditionally the largest shipbuilding nations in Europe followed by countries such as Romania, The Netherlands, Poland, Croatia and Spain. Turkey has grown very fast and is now among the top four in Europe in terms of total order book.

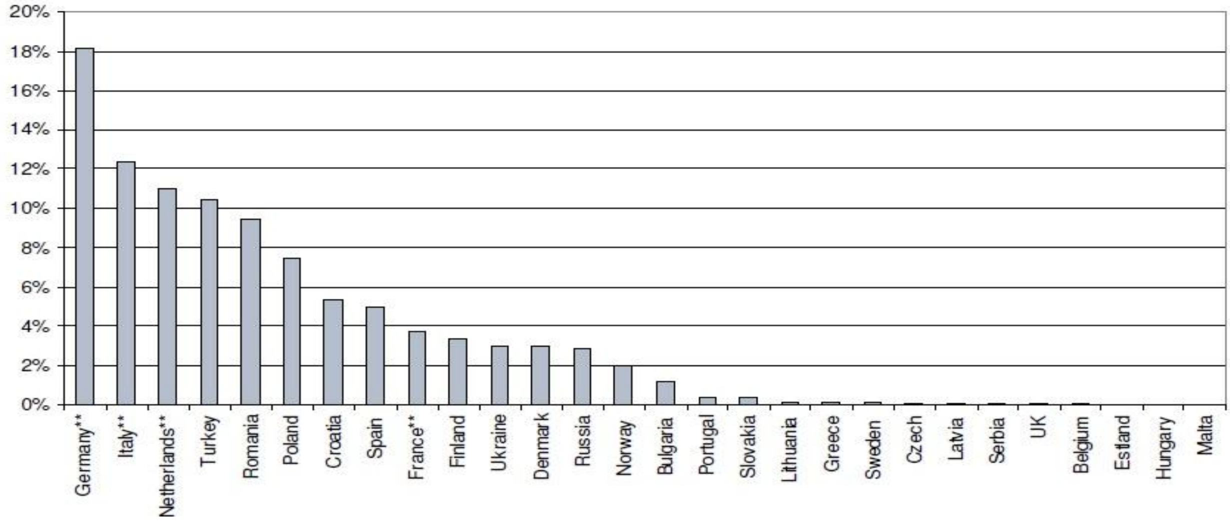


Figure 2.8 Relative position of 30 European countries orderbook in CGT, 2007. [3]

A further differentiation by ship type reveals the specialization in the different European countries

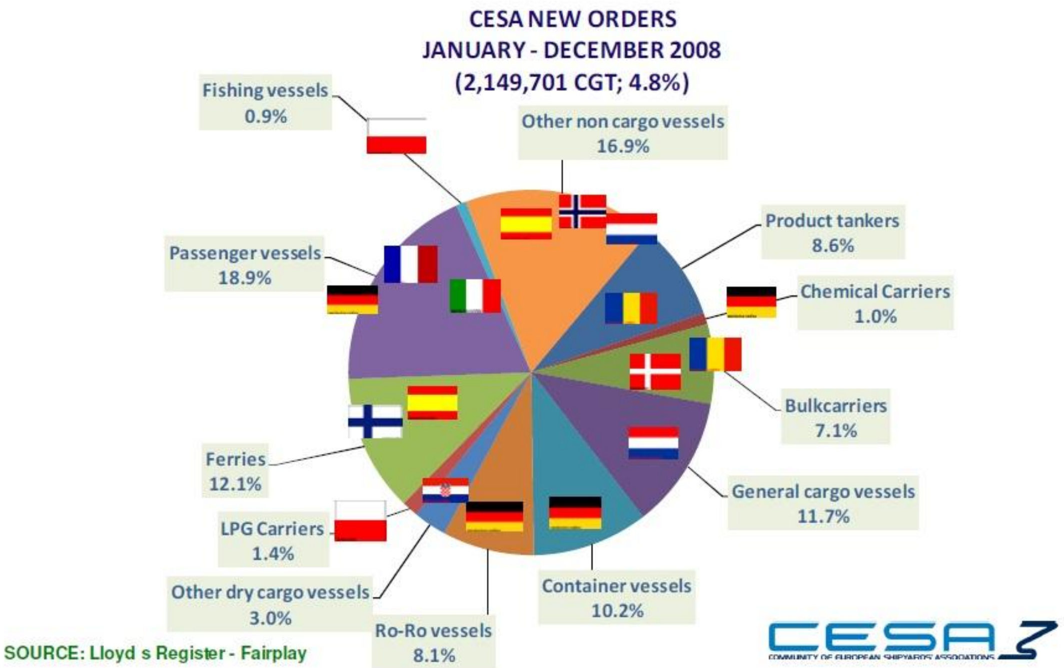


Figure 2.9 Ship type in the different European countries. [3]

Poland and Croatia for example drop in the ranking due to the relatively lower value of ships produced in these countries. In terms of production value, Germany, Italy, Norway and the Netherlands are the top-4 in Europe.

Europe shows a strong export orientation, again reflecting the global character of the shipbuilding market. Between 2003 and 2007, Europe's export rate remained stable.

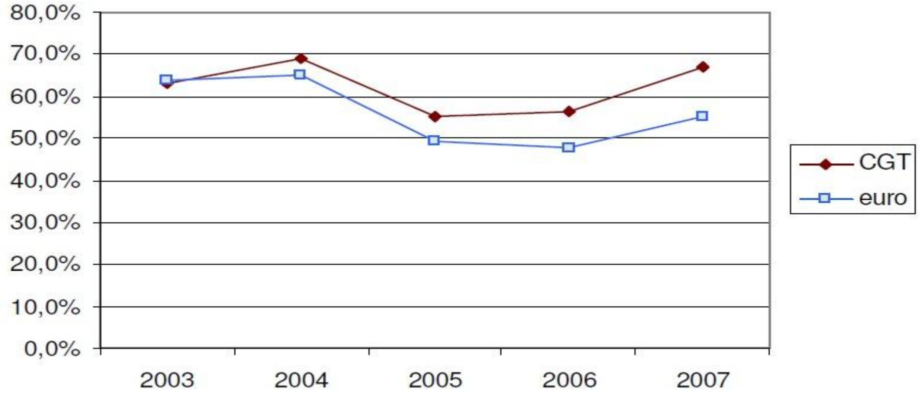


Figure 2.10 Europe's export rate of newbuildings between 2003 and 2007. [3]

The export position of European shipbuilders for a number of major shipbuilding countries

	National clients		Foreign clients	
	CGT	%	CGT	%
Norway	84,024	100,0%	0	0,0%
Germany	594,908	50,8%	576,406	49,2%
Italy	354,203	43,9%	452,000	56,1%
Netherlands	398,022	37,6%	659,919	62,4%
Poland	1,788	0,5%	394,726	99,5%
CESA total	**1,799,195**	**33,0%**	**3,650,241**	**67,0%**

Figure 2.11 Completions 2007 European shipbuilders. [3]

2.1.3. Labour challenges

Lack of qualified workforce was one of the main problems in most of the European shipyards which are facing difficulties in recruiting high educated workforce like engineers, naval architects, IT-specialists or skilled blue collar worker.

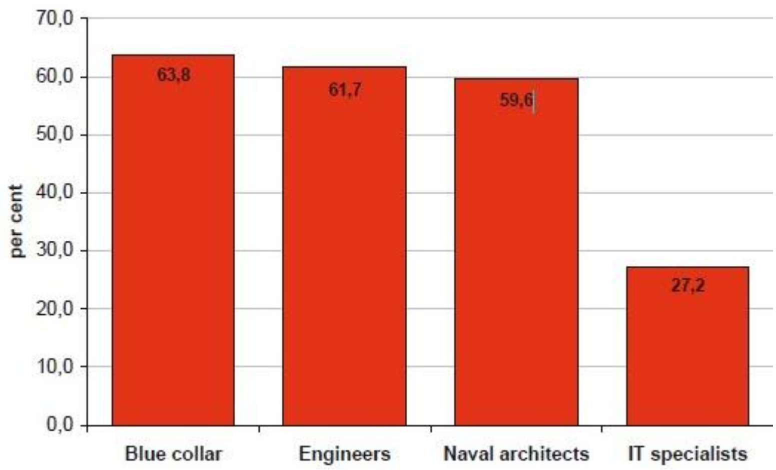


Figure 2.12 Difficulties in recruiting qualified workforce in 2008. [4]

The survey in 2008 showed that most shipbuilders (63.8 per cent) found it difficulties in recruiting skilled blue collar workers, 61.7 per cent estimate a lack of engineers and 59.6 per cent think that it will be complicated to employ qualified naval architects. In addition, the results revealed that there is not such a lack of IT-specialists, probably due to the less specific vocational programs. The shipbuilding sector has developed to be a high-tech industry competing with the aviation and the automotive industry. Bedsides external reasons of the lack of qualified workforces, there are internal reasons of the decreasing in percentage of the permanent (core) staff and the increasing in temporary employment. The occupational skilled workforce has been partly externalised. As a result, recruiting qualified worker in shipbuilding became difficult.

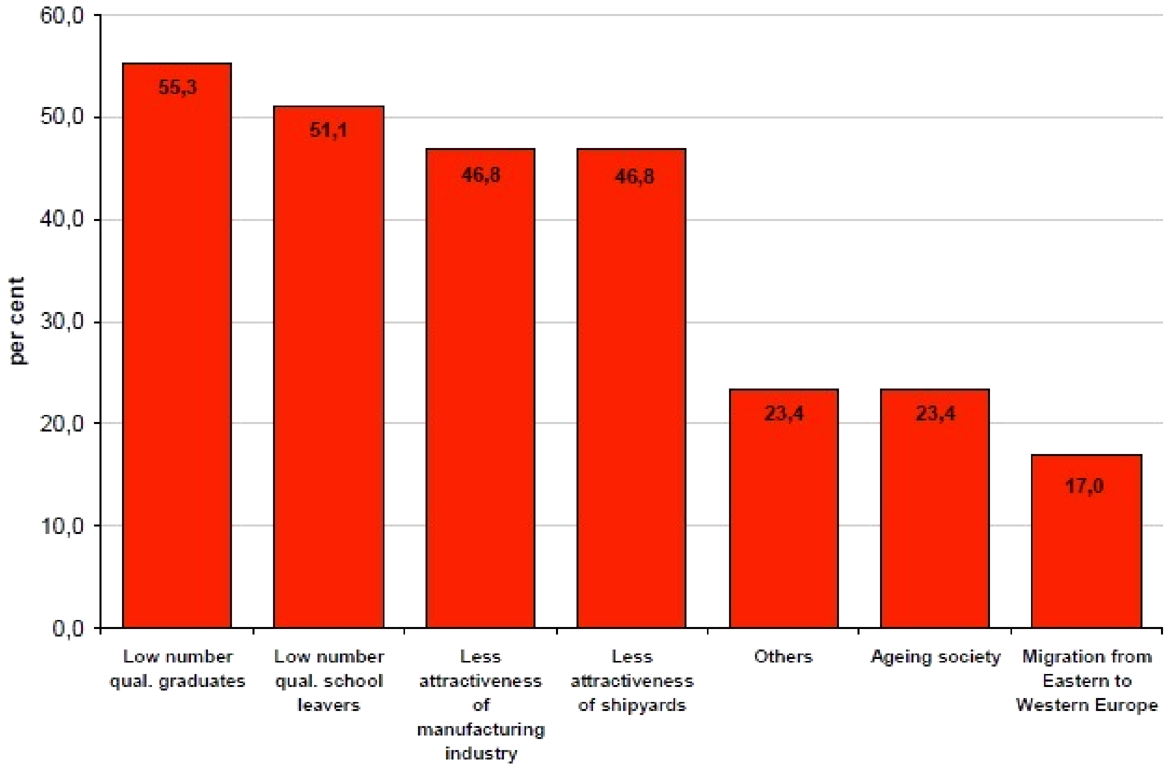


Figure 2.13 Reasons for the difficulties in recruiting qualified workforce in 2008. [4]

There is a reason why the European shipbuilding industry has difficulties in recruiting qualified workforce is the missing attractiveness of the manufacturing industry in general and the low popularity of the shipyards in particular. This problem is caused partly by the bad image and partly by the situation of the European shipbuilding industry before 2003 with the interdependencies of the cyclical processes of the recent decades.

Young people have become less and less interested in this industry. Beyond, the shipbuilding industry is called 3D-Industry, 3-D stands for “dirty, difficult and dangerous”.

2.1.4. The competitive strength of the European shipbuilding industry

Europe has developed into a strong niche player in specialized high-end markets (yachts, cruise vessel, specialized offshore markets), while mainstay market segments (bulk, tanker) have tended to be taken over by Asian competitors.

On the other hand, this is also clear opportunities exist in retaining the European market position. Europe is strong in innovation, renowned for its high quality deliveries and strong collaboration between marine equipment manufacturers and shipyards. This basis can be used to utilize opportunities in the field of new markets that are explored on the basis of Europe's current lead position in complex segments.

Strengths	Weaknesses
• Level of innovation • Innovative SMEs and strong position of marine equipment industry • Strong linkages yards & marine equipment: • Efficiency • Specialisation in niche markets • Spillovers between defence and commercial segments	• Cost levels (wage levels and steel prices) • Access to skilled labour • Access to finance • Potential difficulties in knowledge protection (especially among SMEs) • Fragmented government responses
Opportunities	**Threats**
• New segments, continuous innovation • Greening of shipbuilding industry • Existing transport policies (greening of transport, increased transport quality) • Enhanced requirements regarding shipping standards	• Demand shift from European to Asian buyers • Strengthening of maritime cluster (including finance in Asia) • Increasing development of marine equipment industry • Competitors moving up the ladder • SMEs not surviving the crisis • Flexible and swift competitor's governments to support their industry • Critical mass required to maintain/refresh high skilled workforce. Europe may be too small compared to competitors. Ageing workforce • Price competition in light of economic crisis

Figure 2.14 Summary of economic challenges. [2]

2.2. Technical challenges

The ships are made from tons of steel and aluminium as well as a variety of materials that vary from the most common to the very exotic. Furthermore, every vessel might install hundreds or even thousands of kilometres of pipe and wire equipped with sophisticated power plants and electronic devices. They must be constructed and maintained to withstand with the most hostile of sea state conditions, while providing comfort and safety for the crews and passengers aboard and successful completing their missions.

Designing and construction of the ship have to meet many requirements of ship owner and differ from owner to owner which always forces design team to solve new problem in many aspect, for example arrangement, larger space for common area (movie theatre, opera) while achieving same strength and light weight. This is also subjected to comply with frequently changing regulations and rules of IMO or classification society in order to be safe for environment and people. Many technical functions that ship must satisfy for operating at sea, for example seaworthiness, stability in various sea state and loading conditions make design and construction is even more challenge.

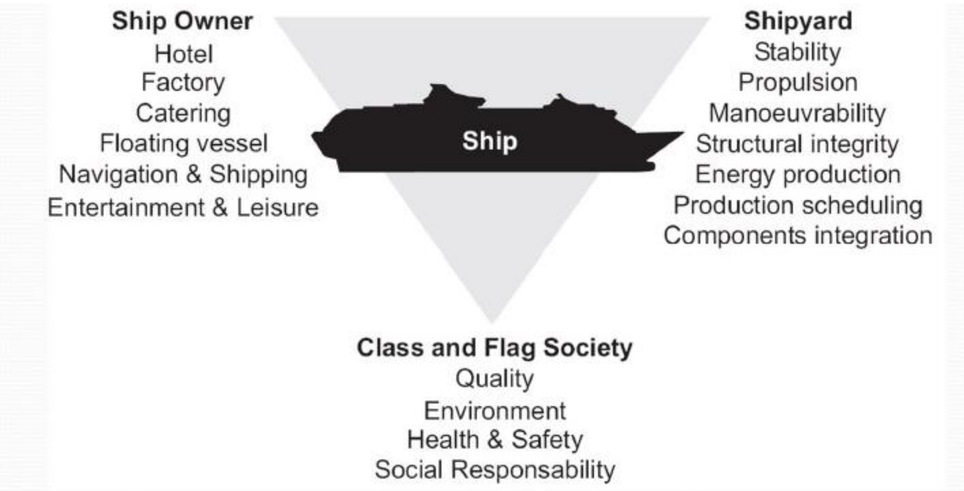


Figure 2.15 Three stakeholders. [12]

The construction of a ship is a highly technical and complicated process involving the blending of many skilled trades and contract employees working as a team under the control of a primary contractor. Construction of small number of entities in relatively short building time requires design production should drive for simplicity and be the best suitable for given shipyard facility.

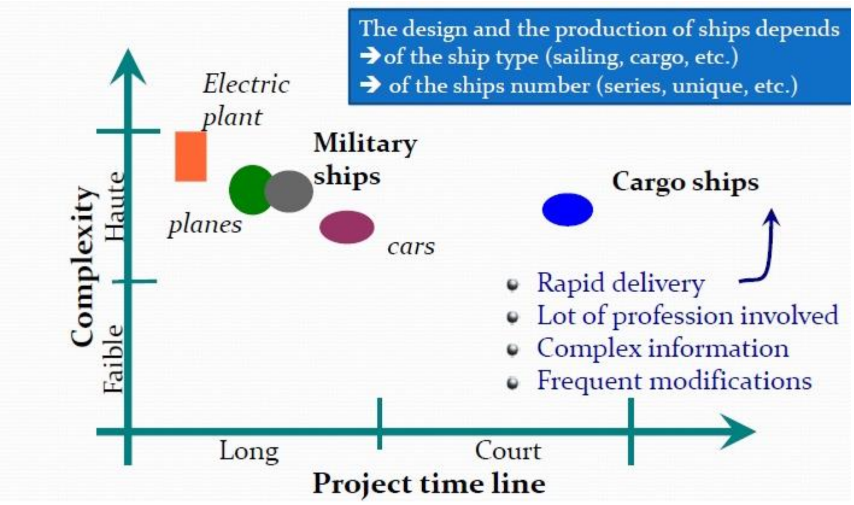


Figure 2.16 Complexity versus project time line. [12]

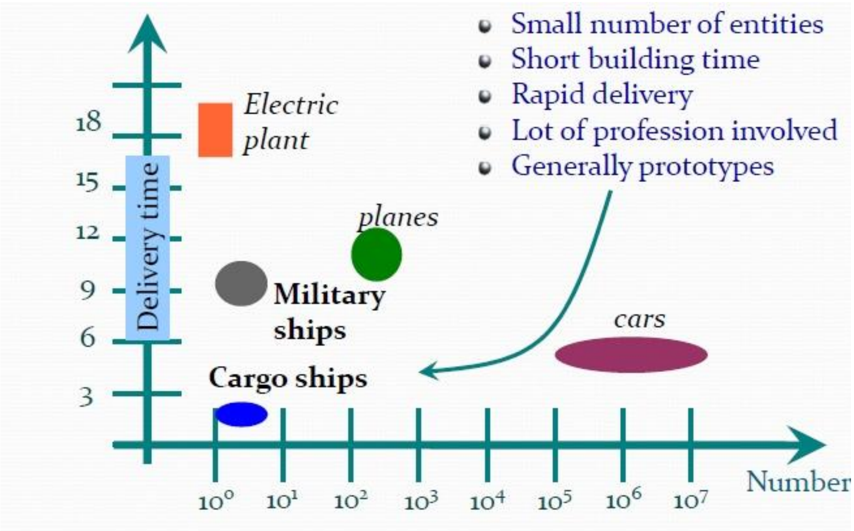


Figure 2.17 Delivery time versus number of units. [12]

Shipbuilding method has changed dramatically since the 1980s. At the early stage, most construction took place in a building or graving dock, with the ship constructed almost piece by piece from the ground up. However, thank to advances in technology and more detailed planning has made it possible to build the vessel in sub-units or modules that have utilities and systems integrated within. Consequently, the modules may be relatively easily connected. This process brings many advantages, such as faster, less expensive and providing better quality control. Further, this type of construction facilitate itself towards automation and robotics, not only saving money, but minimizing exposures to chemical and physical hazards.

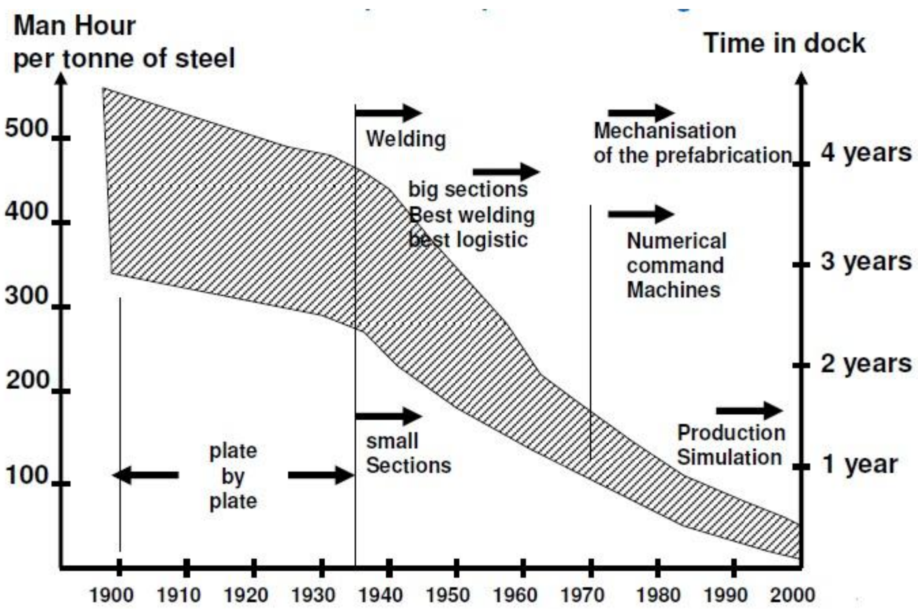


Figure 2.18 Productivity and lead time. [12]

Other technical challenge factors:

- Limited products
- Short time to market
- High complexity
- Bad working conditions
- Low standardisation
- Confined space and bad accessibility
- Ship size
- Design loop

3. ANALYZING CONDITIONS OF SHIPYARD

3.1. Location of shipyard

Szczecin holds the position of the administrative and economic centre of the Westpomeranian Voivodeship, being also the capital of the Pomerania Euroregion and a hub of political, social and cultural cooperation for local authorities from Poland, Germany and the Scandinavian countries. Its cross-border location, academic and scientific potential, and collaboration with neighbours form the stimuli behind Szczecin's development. Szczecin is proximity to the German and Nordic markets (convenient location, diverse and highly-developed transport infrastructure, lower production costs, human potential resource). [6]

Area	301 km^2
Population	410 000
Population of the Szczecin Metropolitan Area	640 000
Population of the Westpomeranian Voivodeship	1 690 000
Number of students	52 000
Unemployment rate	10.5 %
Number of employed	92 400
Average monthly wage - gross	PLN 3 400
Number of business entities per 10,000 residents	1 600
Foreign capital in enterprises	PLN 898 mln

Figure 3.1 General information of Szczecin. [6]

Water transport:

There is a seagoing Szczecin-Świnoujście Port in Szczecin, one of the largest port complexes in the Baltic region, located in the middle of the city, facilitates trade with the most remote regions in the world – West and North Europe, China and Africa. It is also the closest and the most important sea transit port for the Czech Republic and Slovakia.

It is able to access to the European inter-land waterway system through the Oder – Havel Canal with Berlin and river ports of the Western Europe.

Location on the shortest sea route connecting Scandinavia to Central and Southern Europe, and the sea route which connects Finland, Russia and Baltic countries to Germany and the Western Europe through the Baltic Sea.

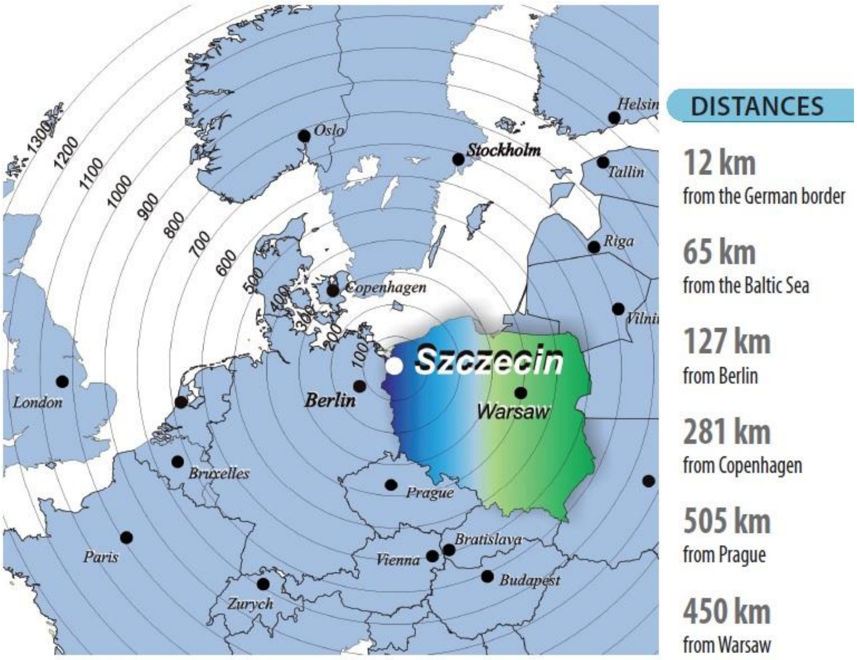


Figure 3.2 Location of Szczecin to other parts of Europe. [6]

- The port of Szczecin is 68 km from the sea. Walking on the shipping route from the roadstead in Świnoujście to Szczecin takes about 4 hours. The port can accept vessels with a draft of up to 9.15 m and a length of 215 m. It is a universal port. There are plans to deepen the shipping route from Świnoujście to Szczecin to 12.5 m in the future.
- The port of Świnoujście can accept vessels with a draft of up to 13.2 m and a length of 270 m. This is the biggest terminal in Poland which serves dry bulk cargo, and a ferry terminal equipped in five bays to operate passenger and car ferries.

As results, the perfect connection of Szczecin with the European and national road system, high-volume water transport opportunities, and the availability of industrial areas, create uniquely-beneficial conditions for the production of advanced, high-volume welded constructions for ships, docks, offshore and inshore use, wind towers, masts, bridges, overpasses, trestles, tanks, gantry cranes, cranes, conveyors, transporters, pipelines, chemical installations, depots.

The natural environment in itself leads to a significant challenge for construction, especially out of doors shipyard work. Shipyard located in northern part of Earth have to deal with winter, for instance slippery conditions wrought by ice and snow, short daylight hours and the physical effects on workers of long hours on cold steel surfaces, often in uncomfortable postures. [6]

3.2. Organization

The main goal of the Management of the company FINOMAR Sp. z o.o. is providing services within the frames of its business activity in compliance with Polish legal system, customer's requirements and ISO 9001:2008 standard.

FINOMAR Management undertakes in its commercial activity to abide by provisions of the Quality Management System implemented at the Company in conformity with requirements of ISO 9001:2008 standard "Quality Management Systems – Requirements" and to improve continuously its activity within fields covered by the Quality System.

The Company is striving at:

full customer satisfaction and its stay with the Company

This goal is realized through:

- setting goals for improvement of each division of the Company,
- fixing measurable quality goals that should be achieved in specified time,
- periodical reviews of the Quality Management System in accordance with ISO 9001:2008,
- increasing awareness of the personnel and overall commitment of all employees to quality issues,
- precising quality requirements in the concluded contracts and accepted orders,
- consistent realization of the agreed conditions
- raising professional and general qualifications of the employees.

FINOMAR Management ensures that this policy is known and understood at all levels of the Company organization.

FINOMAR Management undertakes to make periodical reviews of the quality policy with a view of continuous improvement of the Quality Management System, updating it and keeping in conformity with the development of the Company.

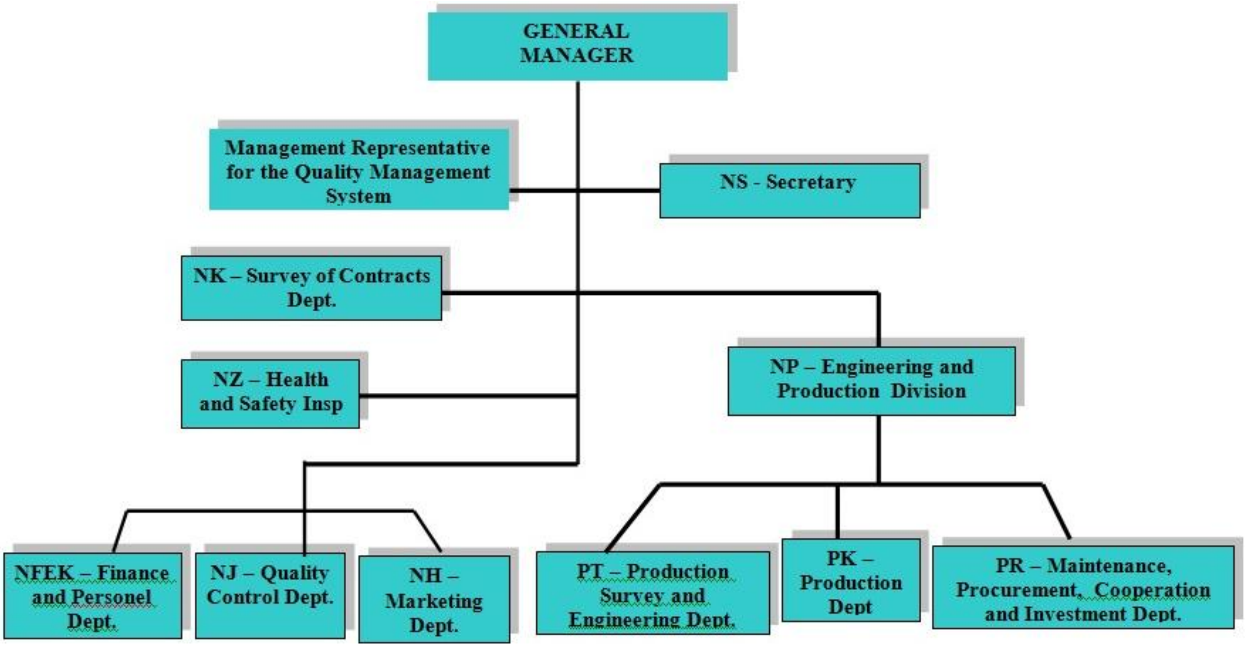


Figure 3.3 Organization structure of FINOMAR shipyard

3.3. Labour resource

3.3.1. Labour disadvantages

3.3.1.1. Education level

The shipbuilding industry employs very labour intensive when compared to other manufacturing industries and requires a well-trained and craftsmen-oriented workforce. One indicator of high-tech industry is the education level of the high-skilled workforce working in this industry

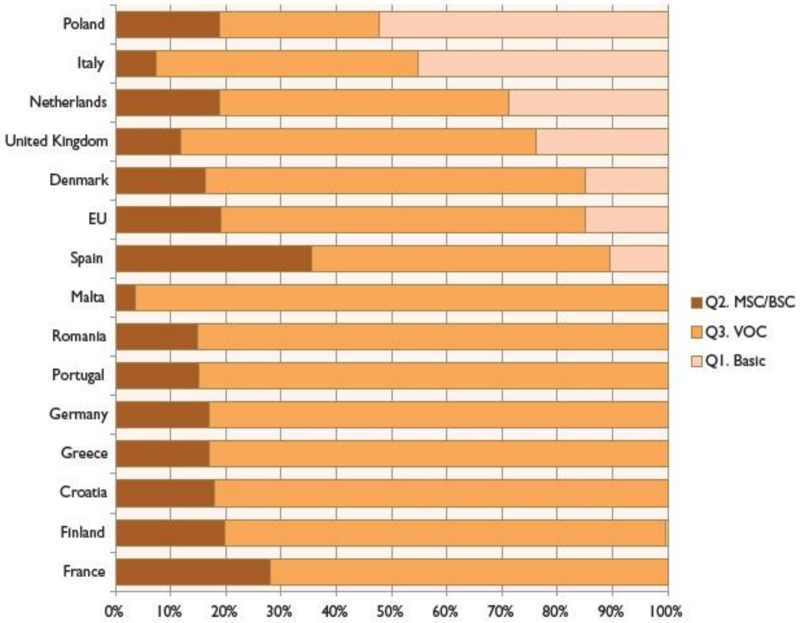


Figure 3.4 Shipbuilding workforce sorted by basic education level. [4]

In overall view, at present, all employees starting to work in the European shipbuilding industry have either a vocational certificate or a Master's or Bachelor's degree. Employees without any vocational certificate or tertiary education are gradually disappearing from the shipbuilding industry.

Going to detail, from this graph one can see that Poland has low shipbuilding workforce with nearly 20% of the employees holding a Master's or Bachelor's degree but the proportion of basic worker is highest with over 50%. Spain even reports 35% of the people working in the Spanish shipbuilding industry with tertiary education. Another indicator for the education level is the number of employees with a highly skilled vocational training working in the industry. A small percentage of 25% of the employees working in the Polish shipbuilding industry have undergone vocational training and finished their studies with a vocational certificate that is not sufficient for the need of high demand workload.

Therefore, many Polish shipyards should have training programs for ail trades in the shipyard to increase the level of worker to be able to perform better quality and high demand for recent projects that also achieve a competitive advantage. Although these training programs are expensive and time-consuming, it is an attempt by the shipyard to maintain a skilled and productive workforce.

3.3.1.2. Aging workforce

The ageing workforce is other factor determining the competitiveness for shipyard and national shipbuilding industry.

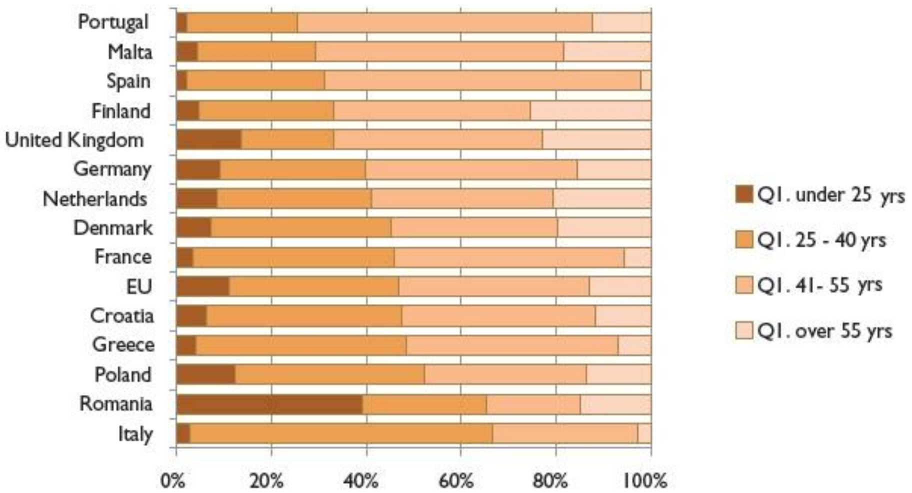


Figure 3.5 EU-14 Shipbuilding technical workforce - age distribution. [4]

Polish shipbuilding workforce matches the average European figure. This structural age workforce is sustainable in long term development. The high amount of pre-working age is need for future because the youngster have better access with high tech technology such as new coming software and new knowledge. They are also enthusiastic, active and good physical condition which suitable for stressful job always requires quick decisions and new solutions. As results, the high percentage of young people in Polish is considered as reservation resource, since becoming a skilled worker usually takes about five years of working experience and properly comprehensive education. The working age worker is the main resource for company. Many positions in the shipyard demand from 3 to 6 years of training and experience.With their experience in specific tasks they can reach high productivity. This proportion, thereforce , should account for slightly 80% of workforce.

3.3.1.3. Migration

A large number of shipyards, especially private and small companies, experience frequent shortages of skilled labour. Low wages, high labour turnover (layoffs and resignations), and instability of workload are main reasons for a substantial demographic move of shipbuilders towards Western Europe where there a need the need for skilled workers and higher salary. A possible explanation for the larger need for technical personnel at all levels in these countries is the relatively old workforce. Another factor which plays a important role is a large share of so-called “other services” which also require shipbuilding skills, such as mechanical and electrical engineering.

The Polish shipbuilding industry association Forum Okretowe estimates that 5,000 Polish people are working in the Norwegian maritime industries. About 30% of these people are working in Norwegian shipyards as shipbuilders, welders or pipefitters. Many Polish shipbuilders are also employed in Germany the United Kingdom, Ireland, France and Finland.

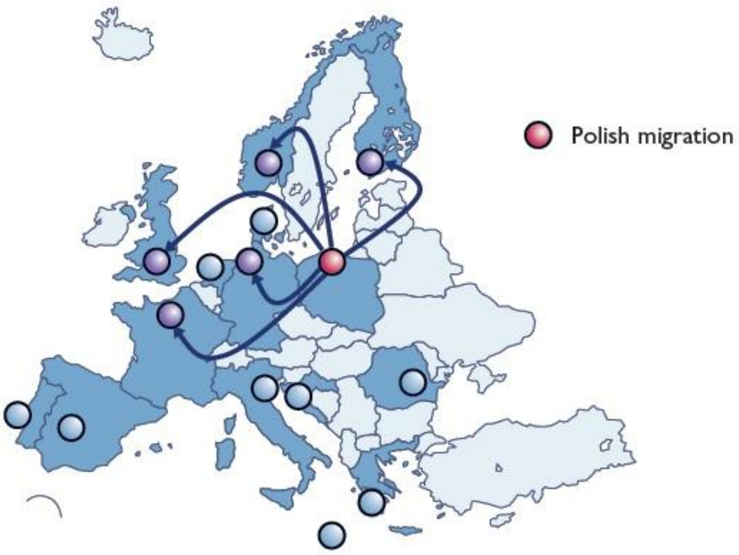


Figure 3.6 Migration of Polish workers. [4]

Therefore, when shipyards lose these highly skilled employees, short-term training programs cannot adequately provide the same level of skills that is needed.

To against this trend, shipyards have to remain a backlog of orders to keep skilled workers in the company and continual development of newly skilled workers that is necessary to keep Polish shipbuilding alive.

3.3.2. Labour advantages

The data collected in 2003 and 2007 reveals the average total costs for a blue collar worker in Poland is second lowest with around 10.000 euro 4 times less than that of Finland and Germany where payment for employee is 46.000 euro. That is one advantage for Polish shipbuilding in competition in Europe to have reasonable price for contract that can help them receive more order book than those countries having much higher price due to expensive labour cost.

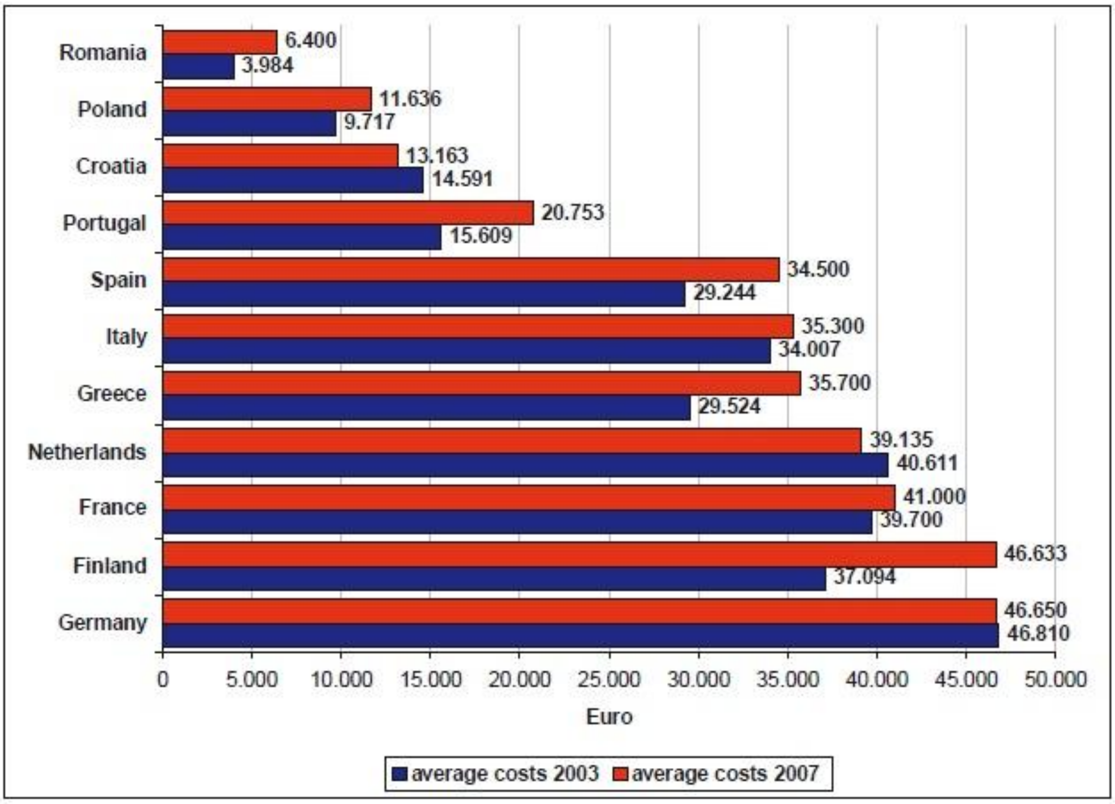


Figure 3.7 Average total costs for a blue collar worker in 2003 and 2007 (Euro). [5]

The annual working time differs from country to country with 1.605 hours in France to 1.950 hours in Norway. The contractual working time could be considered as an indicator for the order books. If the contractual working time in one country is higher than that of another country, their shipyards is booked up to a higher level but it is carefully determined in case the obsolete technology usually consume more time to accomplish the same work. It is in fact that Germany, the strongest and most advantage shipbuilding country, does not have the highest number of annual working time but still produce biggest amount of order book. Poland with the average level shipbuilding technology has the highest annual working time in Europe in 2007 of 2.000 hours which prove a good picture for their business.

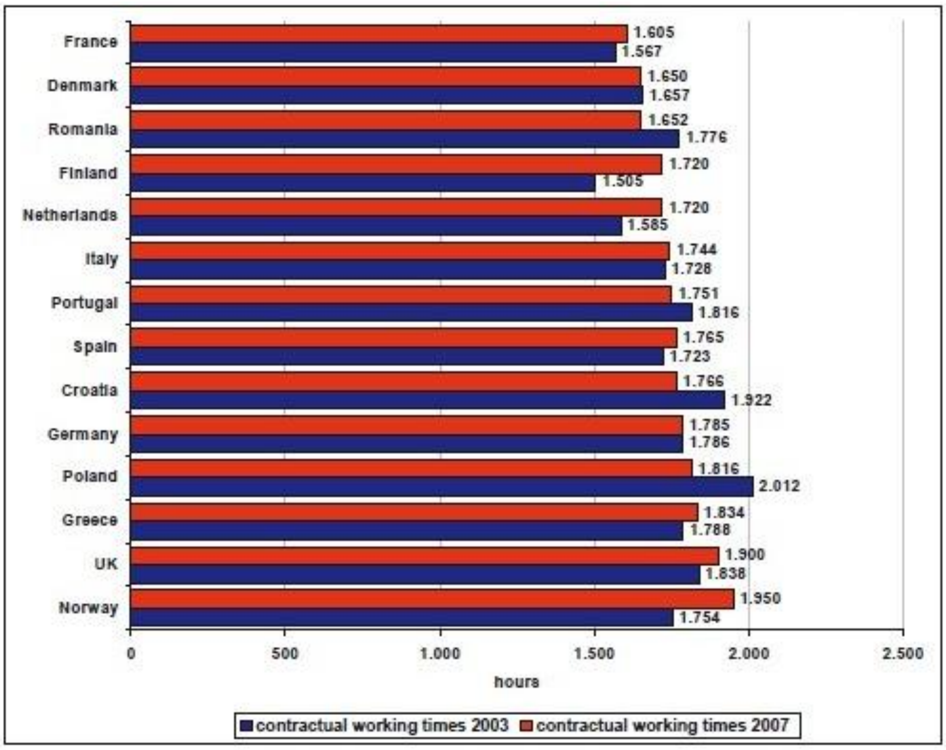


Figure 3.8 Contractual working time of a blue collar worker in 2003 and 2007 (hours per year). [5]

3.4. Collaboration

3.4.1. CLUSTER

Structural Improvements in Industry (Associations, clusters) – The analysis of the marine industry structure shows that a large number of companies and nearly half of the employment is not represented by any industry association. The reason for that is many companies are very small and regional companies, but also mid-sized companies are not required to be member of any association. Clusters are created in order to enhance and accelerate innovation and improve access to knowledge and know-how. The main tasks for clusters consist of, inter alia, attracting foreign investors in cooperation with other clusters, and sharing experience related to business and administration among companies associated in a cluster. In addition, it would be beneficial if regional cluster organisations would have an attempt to get these companies somehow represented or teamed-up, for joint marketing exercises. Clusters also strengthen their structures and activities as well as should be involved in order to accommodate the integration process and to interlink with typically supporting associations.

Cluster organisation is a body responsible for development and animation of interconnections and collaboration within the cluster, as well as for provision of specialised services for cluster members/constituents (enterprises in particular).

CLUSTER is a geographical concentration of specialised entities such as enterprises, research organisations, business support institutions and public bodies, that are defined by strong interactions, represent similar and/or complementary industries and cooperate and compete at the same time. [13]

Clusters can be characterised by the following specific features:

- involvement of entities representing business, research and public administration;
- high level of interactions between cluster constituents;
- concentration on a specific industry/industries;
- geographical concentration and awareness of territorial identity of the cluster;
- formal cooperation/cluster agreement
- dedicated cluster management organisation.

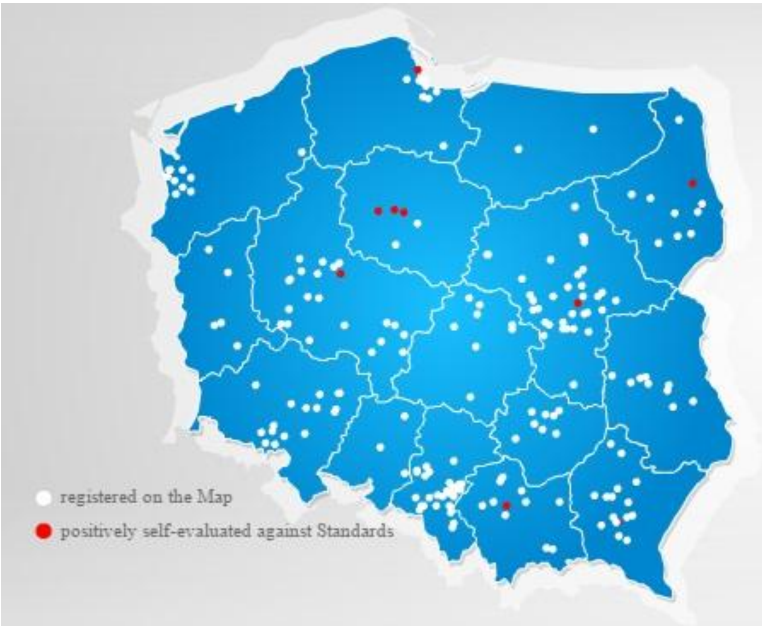


Figure 3.9 The overall distribution of polish clusters. [13]

Good examples in Szczecin Cluster show that this has a large impact on all maritime partners. Co-operation between companies in clusters should be enhanced by advanced networking activities in order to strengthen their special work that bring them back highest profit which it is benefit for all of parties.

cluster main branch:
shipbuilding

number of cluster members:

enterprises	71
science	2
business supporting institutions	7
other members	18

number of enterprises:

micro (to 9 per.)	33
small (10-49 per.)	22
medium (50-249 per.)	11
large (more than 250 per.)	5

cluster infrastructure:

research centre	2
specialised laboratory	0
conference room	2
training base	2

territorial range of market impact:

local	x
regional	x
supra-regional	x
national	x
european	x
global	-

cooperation with foreign partners from:
Czech Republic, Denmark, France, the Netherlands, Germany, Norway

Figure 3.10 Szczecin Cluster information. [13]

3.4.2. University

Shipbuilding builds their capabilities on a strong academic/educational framework with well-developed engineering skills, a strong general industry base and healthy competition in their markets. It is therefore strongly recommended that on the basis of existing programmes education and training in the marine disciplines are enhanced, maintained and if necessary adapted to the demand of new emerging markets and technologies. Industry and universities are requested to jointly develop adequate curricula and to offer related studies. This may also include maritime programmes to establish and support lifelong training measures and as inter European educational exchange programmes.

The development of the production of welded-steel constructions is supported by the local tradition of the region and the potential of a well-trained group of engineers, builders, welding technology engineers and welders, as well as well-equipped research laboratories at the West Pomeranian University of Technology in Szczecin actively cooperating with the industry.

3.5. Ship contract

The beginning of construction is to find contract which is responsibility of Marketing department. They are searching regional and global market but mainly working with certain clients from Germany, Norway or Finland. In low order period, shipyard agreed to construct small unit or work as subcontractor for another company with relative low price to remain continuously working for employees. There are several main gates to contact with new client. The most effective way through Cluster which have reputation for client's belief. Advertising and giving offer are also active channels to look for potential clients. Taking part in marine exhibitions is also direct contact with high opportunity of success.

The ship owner sends out a Request for Proposal (RFP) and the shipyard responds with a proposal for the construction contract. This contract contains the main objectives of ship to be built which are further detailed on ship specification. In order to answer RFP the technical department has to work carefully to calculate the weight of steel constructed with referring previous projects that are as similar as possible to achieve precise price. Man hours price is the main key factor and typical for each shipyard which can distinguish the level of technology and productivity of these company. Throughout long term of experience in practical production this criteria is expected to increase which also means growing in productivity with the development of new technology and intensive labour. Depending of amount of steel weight and man hour price, the technical team provides raw price for construction to marketing department with adding another fee for tax, exchange rate currency or other economic factors to give final price to owner. Ship building contracts can last anywhere from several months to some years, depending on the complexity of the ship. The project manager of shipyard should pay great attention not only for price and also the available work load in current circumstance and during production period. Over load that can lead to failure to deliver a ship on time can result in expensive fines for the shipyard so that the decision of taking new project is crucial. By planning production schedule carefully for some oversee period of time, the balance of workload and workforce have to be compromise to gain the maximum profit.

In undesirable situation of over load, subcontractors are used for sharing activities in the shipyard to help even out the manning and even night or extra shift occurs to ensure time for project, although the extra time is high price.

The selection of client for design should be decided on the basic requirements which are the vessel's objectives. After selecting an appropriate project, ship-owners may require their own technical staff to prepare the tender specification and transfer this to shipbuilders who wish to tender for the building of the ship. The successful tendering shipbuilder in co-operation with the owner technical staff then produced the final building specification and design. It is common that ship-owner hire the consultants to assist them in evaluating the tenders and oversee the construction. This is benefit for ship-owner if they do not have enough technical staffs to perform this task while consultants have solid experience and also guarantee the quality of works. In another case, clients can deliver the vessel's objectives and parameters and shipbuilder has all rights to prepare design and production drawing under supervising of classification society and ship-owner representatives.

European shipbuilding contracts are based on CESA – Community of European Shipyards Associations, one of three most common standard forms of contract which have been established to obtain some uniformity in the contract between builders and buyers. [10]
The CESA standard form of contract includes:

1. Subject of contract (vessel details, etc.)
2. Inspection and approval
3. Modifications
4. Trials
5. Guarantee (speed, capacity, fuel consumption)
6. Delivery of vessel
7. Price
8. Property (rights to specifications, plans etc. and to vessel during construction and on delivery)
9. Insurance
10. Default by the purchaser
11. Default by the contractor
12. Guarantee (after delivery)
13. Contract expenses
14. Patents
15. Interpretation, reference to expert and arbitration
16. Condition for the contract to become effective
17. Legal domicile (of purchaser and contractor)

18. Assignment (transfer of rights)
19. Limitation of liability

The most importance document for construction is approved building specification which will form an integral part of the contract between the two seller (ship builder) and buyer (ship-owner) and thus have legal status.

This technical specification will normally include the following information:

- Brief description and essential qualities and characteristics of ship
- Principal dimensions
- Deadweight, cargo and tank capacities, etc.
- Speed and power requirements
- Stability requirements
- Quality and standard of workmanship
- Survey and certificates
- Accommodation details
- Trial conditions
- Equipment and fittings
- Machinery details, including the electrical installation, will normally be produced as a separate section of the specification.

The paper below is used as an example of practice specification and main contract between shipbuilder and ship-owner:

CONTENTS

Figure 3.11 Example of shipbuilding specification

3.6. Shipyard facility

3.6.1. Type of shipyard

Shipbuilding is traditionally classed as an assembly industry and divides into two parts:

- steelwork – the pre-fabrication, assembly and erection of the steel structure of the ship
- outfit – the installation of the systems, equipment and fittings into the ship

Today, shipbuilding is known as automation and robotize of the industrial operations which increases its efficiency and productivity. However, it is typical that the very high level of automation as such is not ensure the highest priority in the development and desired plans for the shipyards because one-of-a-type production. The most common processes where the automation are highly interested and applied in following: marking, cutting & conditioning of steel plates and profiles; fabrication of 2D blocks: welding of flat and shaped sub-assemblies (panels and sub-blocks); fabrication of 3D blocks in workshop; prefabrication of pipes, supports, modules; blasting and painting/coating; transport & handling; dimensional control & inspection.

There are 6 levels of technological development of shipyards. It is small amount of shipyards around the world have reached the highest 6th level. The majority remain staying at the 4th level or even lower. The level of the shipyard's technology is one of the most important factors influencing the cost competitiveness, especially for the large enterprise.

Table 3.1 Shipyard technology level. [3]

Level	Description
1	Reflects typical practice of the early 1960s – welded hulls, combination of blocks and assembly at erection, small cranes (<50 t), multiple open berths, post launch outfitting and little mechanization. Manual operating systems.
2	Reflects yard modernization of the late 1960s/ early 1970s. Fewer berths or dock, larger cranes (<250 t), some mechanization and pre-outfitting, numerical controlled metal cutting machines. Some computerized systems.
3	Good practice of the late 1970s, new/fully redeveloped yards, large capacity cranes (>350 t), some weather protection at dock or single construction area. High degree of mechanization and use of computers. Block manufacturing shops.
4	Technology advances of the middle 1980s. Generally large docks, protected microclimate zones, extensive early outfitting and fully developed operating systems. High lifting capacity of Goliath cranes (>800 t)
5	State of the art of the 1990s, with automation, integration of operating systems, use of CAD, CAM, CAPP. Computer aided material control and Quality Assurance. Increased automation and robotics in welding, pipe shops. Goliath cranes (>800 t)
6	2000 to present: large, renovated and some completely covered shipyards, large grand and ultra blocks to 3000 t, mainly robotics for welding and part assembly. Goliath cranes (>800 t)

→ FINOMAR is on level 3 with full characteristics of this type of shipyard.

The European shipbuilding industry is very diverse in company size and structure. The company workforces range from tenths to thousands of employees. The shipbuilding industry is split into two different groups.

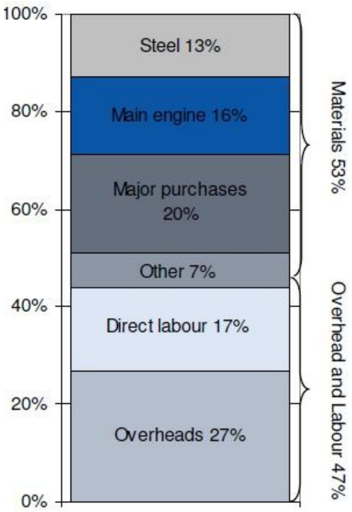
The first group is global players who are active in one or more marine markets. This group is to a large represented by the top 100 companies and also in large or medium sized companies. The second group is the vast majority of companies which is dependent on regional maritime markets or even dependent on single maritime customers. This group of companies is basically consisting of a large number of small and medium sized enterprises, often also located in the close proximity in areas of intensive maritime activities. These two groups have their own different risks and challenges, but also different opportunities in accessing market and in the cooperation with their clients.

FINOMAR plays their market regionally with permanent international customers in Germany and Norway.

Small and medium-size companies are dealing with not have enough financial reserves and may do not survive further critical period until the next booming in new stage. The question is how shipyards will survive. In fact, some countries decide to reduce shipbuilding capacity or even close it before their shipyards collapse. Alternatively, another answer is to increase productivity and more flexibility. Productivity is influenced by technology, facility, management competence, work organization, work practice, the level of workers' skills and motivation. Productivity is the amount of output achieved for a given amount of input (materials, manpower and energy).Besides the productivity (CGT / man year), the competitiveness depends on production range (personnel cost / total cost), attractiveness of product (market price / CGT), S - subsidy ratio, X - exchange rate and K - cost position (labour cost / man year).

The manager has to consider carefully what is most valuable for the shipyards competing in the market. The consideration should survey through every type of work and compares typical production elements such as steelwork and outfitting production, other pre-erection, ship construction, layout & environment, design & drafting, and organisation/operating of the main shipbuilding countries/regions to have clear picture of which can bring highest profit for company suitable with the natural and technical facility shipyard has.

In general, metal hull takes over 50% the material cost of the ship and 50% of the labour cost. In the figure below, the cost breakdown is presented:



Names	Functions	Manpower
Metal hull	Design / Manufacture / Assembly } items of the structure	50%
Energy & Fluids	To ensure the assembly and the correct operation of the hydraulic installations (circuit of water, fuel, conditioned air, etc.)	24%
Electricity	To ensure the assembly of the electric installations on board	9%
Painting and Anti-corrosive	To ensure the protection of the ship against the aggressions of the ambient conditions. To intervene on the problems of watertightness	3%
Accomodations	To ensure the interior decoration of the ship according to the requirements of style and cost given by the ship-owner	14%

Figure 3.12 The cost breakdown for new construction of ship

Therefore, the main work in FINOMAR is for metal hull with a large number of welders. These specialised products made European shipbuilding less vulnerable to factors such as their relatively high costs of steel and labour. The strong position of SMEs (Small and medium-sized enterprises) which are generally seen as an innovative factor can be seen as a key strength. The limited size of European shipyards comparing to their Asian competitors could be seen as a disadvantage (less benefiting from economies of scale), but on the other side it can be argued that as European yards are less focusing on mass markets, thus, these scale economies are less influenced. By contract, for specialised products smaller size may be an advantage and the company is more flexible in adapting to innovations. It may also help to enhance cooperative development between shipyards and marine equipment companies.

In conclusion:

FINOMAR operates in a labour-intensive manufacturing sector that is highly dependent on steel prices.The strength of Finomar and other similar companies in Poland is a widespread belief that Polish smaller yards are better at basic steel components manufacturing and repairs than in the more demanding task of machinery or electrical repairs.
FINOMAR specializes in production of complex welded structures and provides services for the shipbuilding and power industry. Position of the company allows for transport of materials and finished products by land or water. The company is situated on Oder river with further access to sea.

FINOMAR production capacity allows for production of:

- complete floating units, e.g. pontoons,
- hull bodies and/or their parts incl. outfitting,
- construction elements for power station (diverters, exhaust gas ducts, filter casings),
- elements for offshore industry,
- foundations for tower for wind power station,
- steel structures of diverse designation,
- aluminum constructions.

3.6.2. Layout

Some shipyards focus on new building of ships, others on repair and maintenance. Some shipyards focus on specific innovative ship types, others focus on process innovation, building a variety of ship types. Some shipyards build for commercial clients, others for consumers or governments. Because of high volume workforce in both new construction and repair ship in Poland, the third biggest amount of workforce, FINOMAR does variety of work for both new ship and ship repair or even offshore unit.

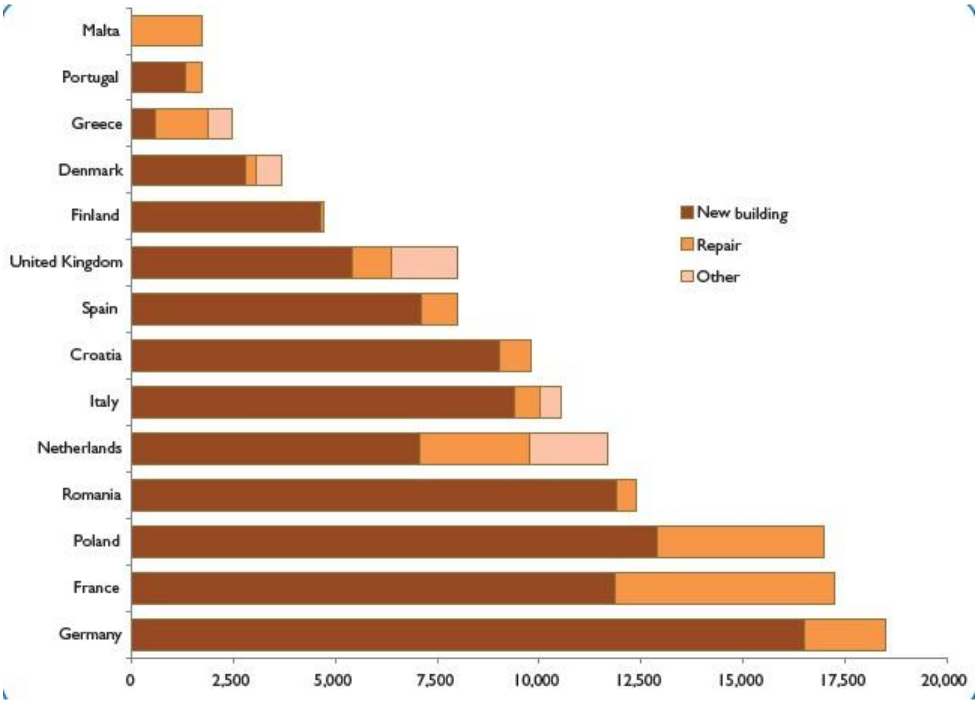


Figure 3.13 Distribution types of works in shipbuilding industry in Europe. [4]

Position of the company allows for transport of materials and finished products by land or water. The company is situated on Oder river with further access to sea allowing the maximum sea deep 12m. Thank to flat topography and natural conditions, there is availability of brownfield land with a total area of approximately 1 hectare, with a coastal area of over 300 m and the necessary dockyard infrastructure cranes, stockyard, warehouses, building and workshop.The shipyard layout is based on a production flow basis, with the yard extending back from the river at which the quay is located. The farthest area from the quay is arranged in sequence the consecutive work and shop processes, and between the two areas is reserved for the material stockyard. Shipyard follows the river bank, and is restricted by their location in a built up area so that it will be restrained as to the size and type of ship that can be constructed.

Building docks can be of advantage in the construction of large vessels where launching costs are significant, and there is a possibility of structural damage due to the high stresses imposed by a conventional launch. In contrast, high initial cost is the greatest constraint of the building dock. For building medium and small unit structure which total weight is relatively small, it is wise to utilize other equipment like slipway or mobility cranes that is both dynamic using and low cost operation without much and costly maintenance.

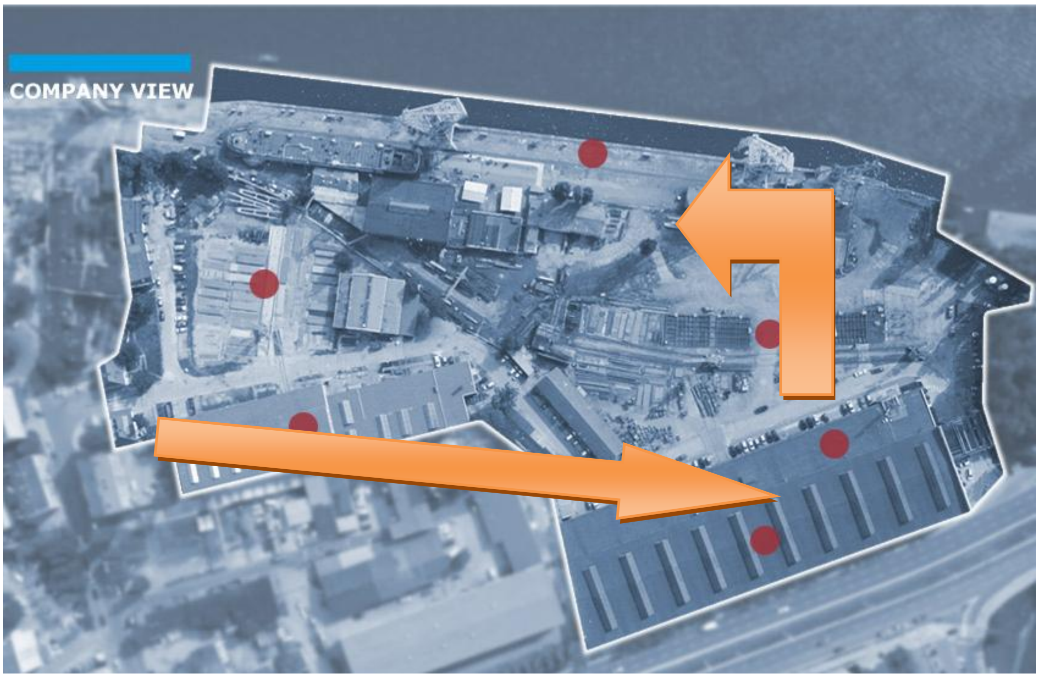


Figure 3.14 Main workflow type used in FINOMAR is U shaped layout

Shipyard layout satisfies performance criteria:

- Cost minimization
- Transportation distance minimization
- Maximization of the volume of transport units
- Maximization of the communication and control

This layout is designed base on some criteria below:

- Physical attributes of the product (size and type of ship to be built)
- Volume of units travelling amongst processes
- Material production per year to be achieved
- Frequency of transportation amongst processes
- Material handling cost (cost per movement x number of movements)
- Machining processes available in workshop

- Unit size and weight capacity can be fabricated and erected.
- Amount of outfit and engine installation to be installed.
- Control services to be supplied.
- Administration facilities needed.

3.6.3. Ship Construction Process

Once a new construction contract is awarded and most of the detailed design and production planning are performed, actual construction can begin.

At design stage which considerations construction parameters for various types of ships vary widely. The basic elements of ship building is steel plates which are cut, shaped, bent or otherwise manufactured to the desired configuration specified by the design.

Shipbuilding process can be broken up into five general manufacturing levels.

The first level involves transforming the raw materials, for example steel plates, steel bars, pipes, sheet metal, electrical, into parts. Therefore purchasing, handling, and production of these raw materials and parts comprise the first level of manufacturing ships.

The second level involves joining the parts and steel members into subsections and sub-assemblies. The sub-assemblies of steel, pipe, venting, electrical and other outfitting are brought together to create the third level of ship construction.

The third manufacturing level yields what are known as the hull blocks or units.

The fourth level of ship manufacture, known as erection involves in these large blocks which are transported through the shipyard and finally joined together onboard to form the ship.

The fifth level of shipbuilding comprises the final installation, completion, and testing of internal mechanisms and systems before the ship can be delivered to the owner.

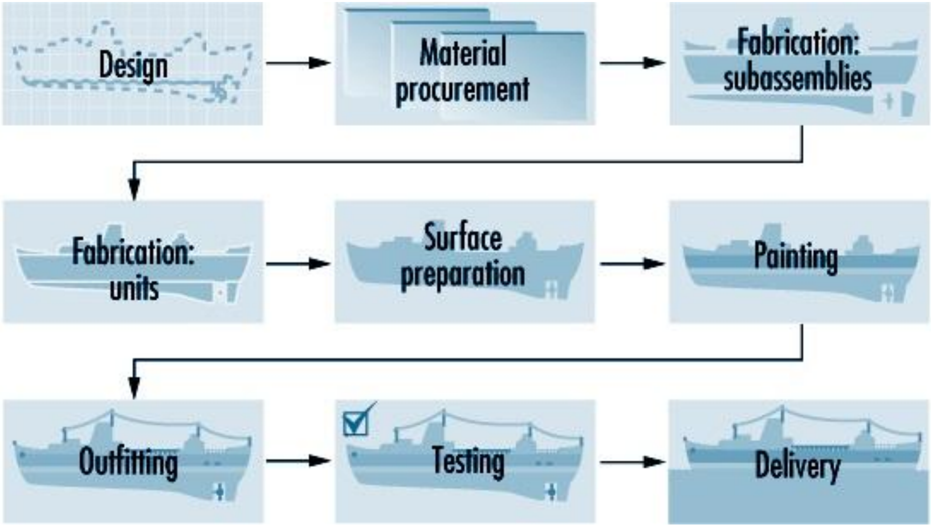


Figure 3.15 Shipbuilding flow chart. [8]

Ship work breakdown structure is used to construct effectively due to several reasons:

- Reduction in engineering drawings
- Company standardization
- Reduction in design and engineering man-hours
- Reduction of the lead time
- Better utilization of the facilities
- Simplified and automated planning
- Simplified scheduling and production control
- Improve productivity
- Better balance between workforce and workload

The general capacity of fabrication shop is presented:

RANGE OF WELDING WORK PERFORMED: **MILD, LOW ALLOYED AND STAINLESS STEEL STRUCTURES, ALUMINIUM ALLOY STRUCTURES**.

Number of employees (total): 220 of which welders / operators: 32

1.Workshop 4825 m^2 area (2 bays)

with lifting capacity: 6 pcs overhead cranes 10–25 T capacity;

Max lifting capacity of 2 cranes – 50 T;

Lifting height 8,5 M

2. Plate preparation workshop 1370 m^2

.with lifting capacity: 3 pcs overhead cranes 3-12,5 T capacity;

3. Quay 330 m

with 3 cranes up to 20 t capacity

4. Covered heated store for welding consumables equipped with
   – Baking oven 300^0 C – 1 pc
   – Heatable container 100^0 C – 1 pc
5. Cutting equipment
   – Oxyacetylene hand torches and semiautomatic machines
   - CNC plasma cutting machine MICROSTEP PLS - 1pcs
   – CNC oxygen cutting machine OMNIMAT/SATO S.A. 2000 - 1 pc
   - Photo-electric 1:1 scale cutting machine CORTA - 1 pc
   - Plasma cutting machine HYPERTHERM MAX 100 - 1 pc
   - Plasma cutting machine HYPERTHERM MAX 43 - 1 pc
   – Carbon arc air gouging machine - 3 pcs
   - Guillotine shears 2,5m - 1 pc
   - Frame saw - 1 pc
   - Band saw - 1 pc
6. Welding equipment:
   - DC welding machines (400 A) - 5 pcs
   - DC multioperator welding machines (1500A) - 2 pcs
   - MMA/MIG/MAG welding machines - 75 pcs
   - MMA/TIG welding machine - 3 pcs
   - SAW tractor type welding machine - 4 pcs
   - MAG tractor type fillet welding machine - 8 pcs
7. Equipment for preheating, heat treatment and temperature measurement:
   Oxy – acetylene burners
   Contact thermometer – 50 ^{0}C ÷ 1300^0C
   Tempilsticks
8. Machining and forming equipment and tools:
   - Equipment for grinding and cleaning
   - Equipment for mechanical cutting and bevelling of aluminium alloy plates
   - Abrassive saws
   - Turning Lathe 150 mm dia
   - Drilling machines
   - Bending press 63 t
   - Bending rolls
9. Available test equipment and test media (for destructive and non-destructive testing):

Visual Inspection, and Dye Penetrant Tests made by ourselves by certified personel; Another Tests (esp.Ultrasonic testing and Radiography of welds) performed by subcontractors – certified AR testing laboratory.

3.6.4. Stockyard

Figure 3.16 Stockyard overall views

On arrival at the shipyard, steel plates and profiles are temporarily stored in the stockyard. According to the rule, the stockyard is an uncovered space having sufficient area to provide storage for enough plates and profiles required for the working of the yard some coming months. There are a large areas for storage of steel with outdoor storage of : **4 375** m².

Thank to be close to steel manufacture, the steel frequently transfers directly to shipyard with short time of waiting so that the process : Heating →Shot blasting→ Primer → Drying, is not necessary. The steel plates then are handed to cutting process by crane and truck.

Steel before coming to shipyard should be classed by specific classification society or is produced by an approved manufacturer, and inspection and prescribed tests are conducted to ensure the quality of material. All classed materials are marked with the Society's symbol and other particulars as required by the rules.

There are now five typical classes of steel used in ship construction and now often accorded to as IACS steels. These are graded A, B, C, D and E. Grade A is an ordinary mild steel and generally used in shipbuilding. Grade B has a better quality than Grade A and employed where thicker plates are required in the some critical areas. Grades C, D and E have better notch-tough characteristics.

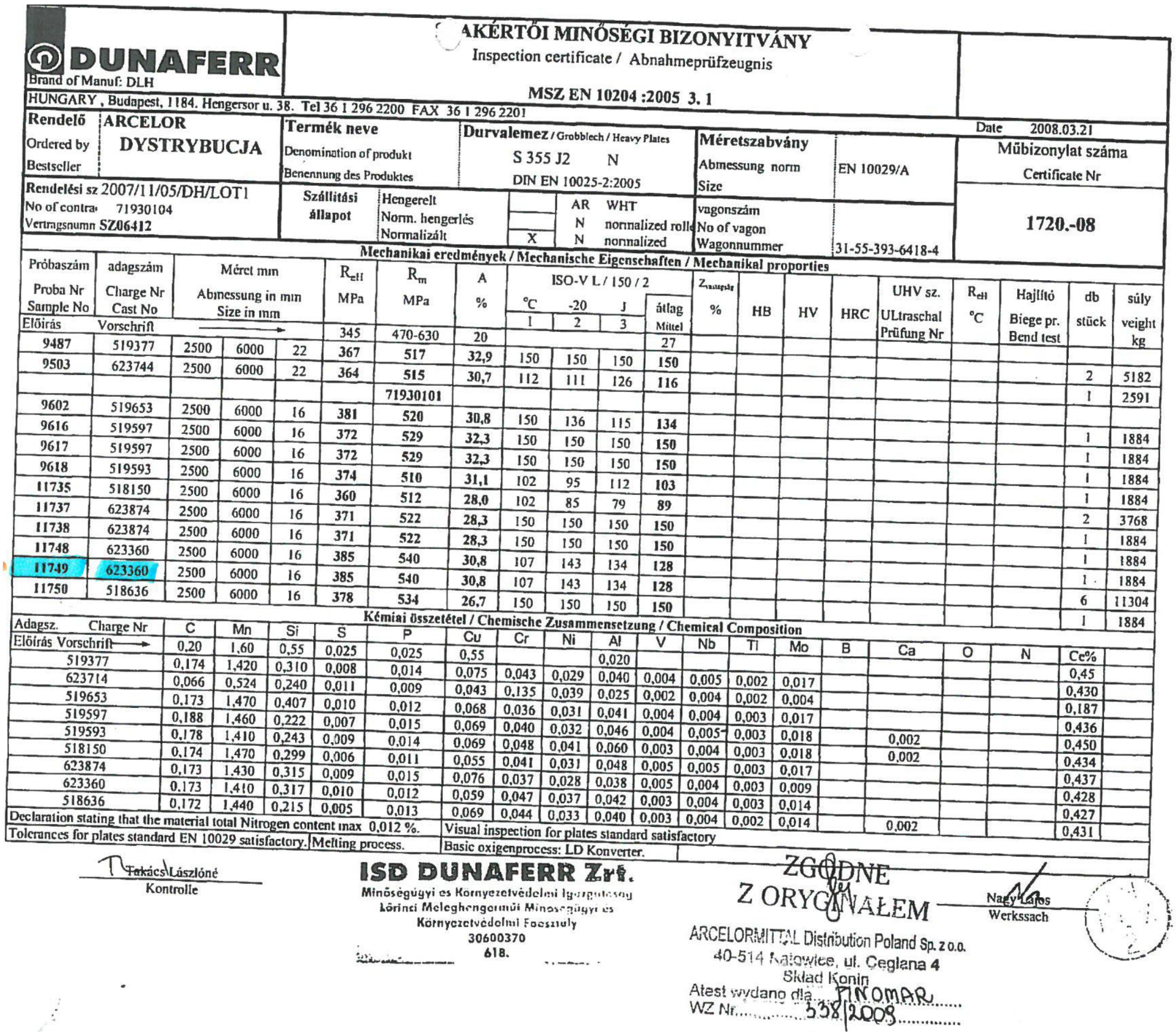
Destructive tests are performed on specimens extracted from the same product as the finished material complying with the requirements of classification society.

Tensile test and impact test are commonly made.

<u>Tensile test</u> is which a specimen of given dimensions is subjected to an axial pull and a minimum specified yield stress, ultimate tensile stress, and elongation must be recorded.

The same proportions of sectional area and gauge length are required for tensile test pieces of the same material to make comparisons between them. The gauge length equal to 5.65 times the square root of the cross-sectional area or five times the diameter is standard gauge introduced by many classification societies.

<u>Impact test,</u> the Charpy V notch test or Charpy U notch test is commonly used to determine the toughness of the material, which is ability to withstand fracture under shock loading. The steel must be excess these criteria to ensure having adequate strength for ship so that the stock yard manager have to check each plates and profiles by material certificates. They also list each steel element to control the number and position in stock yard and it is available on material list.



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AKÉRTŐI MINŐSÉGI BIZONYITVÁNY
Inspection certificate / Abnahmeprüfzeugnis
MSZ EN 10204 :2005 3. 1

Rendelő / Ordered by / Bestseller	ARCELOR DYSTRYBUCJA	Termék neve / Denomination of produkt / Benennung des Produktes	Durvalemez / Grobblech / Heavy Plates S 355 J2 N DIN EN 10025-2:2005	Méretszabvány / Abmessung norm / Size: EN 10029/A	Date 2008.03.21 / Műbizonylat száma / Certificate Nr
Rendelési sz 2007/11/05/DH/LOT1 / No of contra 71930104 / Vertragsnumn SZ06412		Szállítási állapot: Hengerelt / Norm. hengerlés / Normalizált (X)	AR WHT / N normalized roll / N normalized	vagonszám / No of vagon / Wagonnummer: 31-55-393-6418-4	1720.-08

Mechanikai eredmények / Mechanische Eigenschaften / Mechanikal proporties

Próbaszám Proba Nr Sample No	adagszám Charge Nr Cast No	Méret mm Abmessung in mm Size in mm			R_{eH} MPa	R_m MPa	A %	ISO-V L / 150 / 2 °C -20 J 1	2	3	átlag Mittel	Z %	HB	HV	HRC	UHV sz. ULtraschal Prüfung Nr	R_{eH} °C	Hajlító Biege pr. Bend test	db stück	súly veight kg
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						71930101													1	2591
9602	519653	2500	6000	16	381	520	30,8	150	136	115	134									
9616	519597	2500	6000	16	372	529	32,3	150	150	150	150								1	1884
9617	519597	2500	6000	16	372	529	32,3	150	150	150	150								1	1884
9618	519593	2500	6000	16	374	510	31,1	102	95	112	103								1	1884
11735	518150	2500	6000	16	360	512	28,0	102	85	79	89								1	1884
11737	623874	2500	6000	16	371	522	28,3	150	150	150	150								2	3768
11738	623874	2500	6000	16	371	522	28,3	150	150	150	150								1	1884
11748	623360	2500	6000	16	385	540	30,8	107	143	134	128								1	1884
11749	623360	2500	6000	16	385	540	30,8	107	143	134	128								1	1884
11750	518636	2500	6000	16	378	534	26,7	150	150	150	150								6	11304
																			1	1884

Kémiai összetétel / Chemische Zusammensetzung / Chemical Composition

Adagsz. Charge Nr	C	Mn	Si	S	P	Cu	Cr	Ni	Al	V	Nb	Ti	Mo	B	Ca	O	N	Ce%
Előírás Vorschrift →	0,20	1,60	0,55	0,025	0,025	0,55			0,020									
519377	0,174	1,420	0,310	0,008	0,014	0,075	0,043	0,029	0,040	0,004	0,005	0,002	0,017					0,45
623714	0,066	0,524	0,240	0,011	0,009	0,043	0,135	0,039	0,025	0,002	0,004	0,002	0,004					0,430
519653	0,173	1,470	0,407	0,010	0,012	0,068	0,036	0,031	0,041	0,004	0,004	0,003	0,017					0,187
519597	0,188	1,460	0,222	0,007	0,015	0,069	0,040	0,032	0,046	0,004	0,005	0,003	0,018					0,436
519593	0,178	1,410	0,243	0,009	0,014	0,069	0,048	0,041	0,060	0,003	0,004	0,003	0,018		0,002			0,450
518150	0,174	1,470	0,299	0,006	0,011	0,055	0,041	0,031	0,048	0,005	0,005	0,003	0,017		0,002			0,434
623874	0,173	1,430	0,315	0,009	0,015	0,076	0,037	0,028	0,038	0,005	0,004	0,003	0,009					0,437
623360	0,173	1,410	0,317	0,010	0,012	0,059	0,047	0,037	0,042	0,003	0,004	0,003	0,014					0,428
518636	0,172	1,440	0,215	0,005	0,013	0,069	0,044	0,033	0,040	0,003	0,004	0,002	0,014					0,427
															0,002			0,431

Declaration stating that the material total Nitrogen content max 0,012 %. Visual inspection for plates standard satisfactory
Tolerances for plates standard EN 10029 satisfactory. Melting process. Basic oxigenprocess: LD Konverter.

Takács Lászlóné
Kontrolle

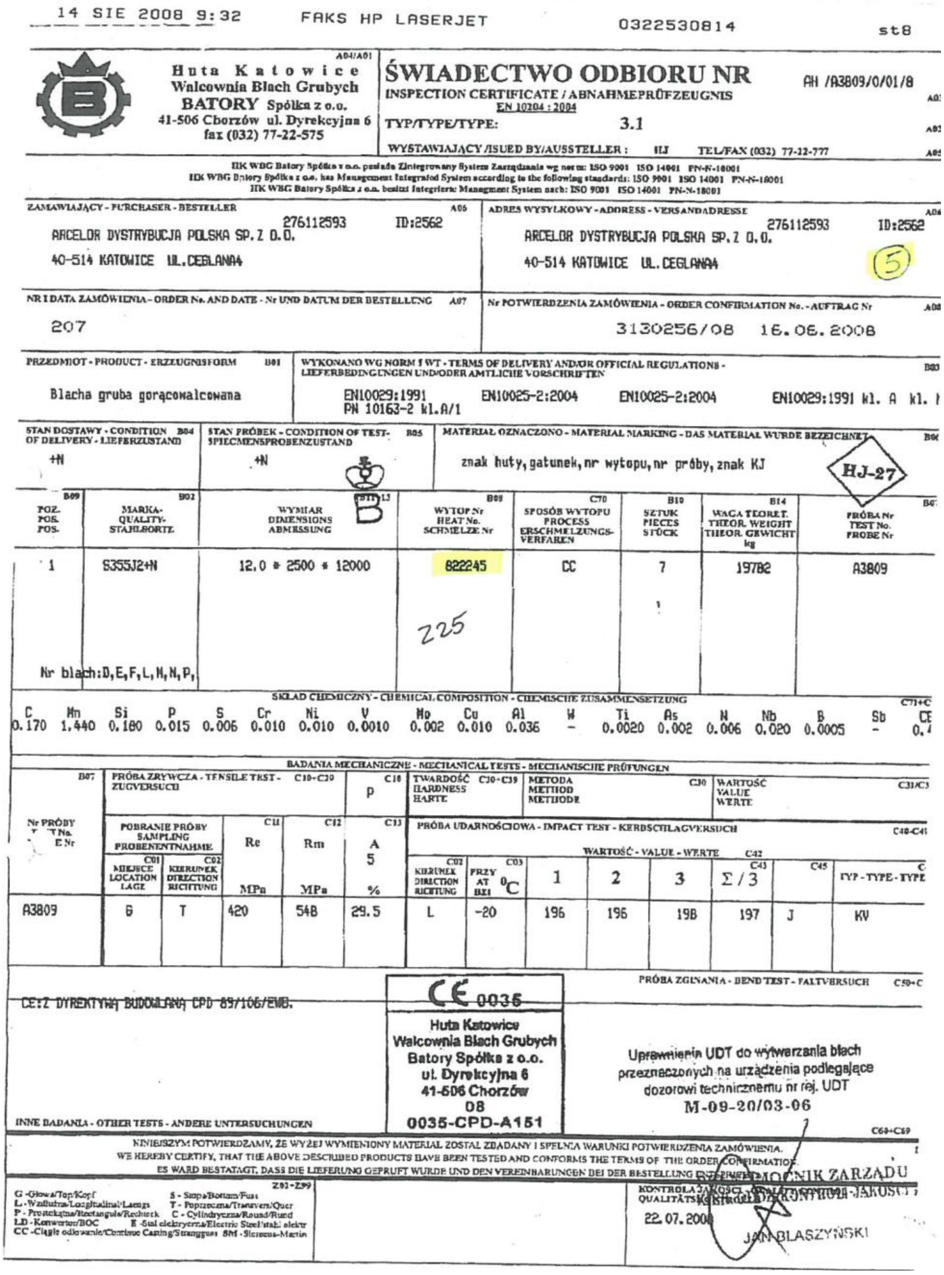
ISD DUNAFERR Zrt.
Minőségügyi es Környezetvédelmi Igazgatóság
Lőrinci Meleghengermüi Minőségügyi és Környezetvédelmi Főosztály
30600370
618.

ZGODNE Z ORYGINAŁEM
ARCELORMITTAL Distribution Poland Sp. z o.o.
40-514 Katowice, ul. Ceglana 4
Skład Konin
Atest wydano dla PINOMAR
WZ Nr 338/2008

Nagy Lajos
Werkssach

Figure 3.17 Inspection certificate for strength of material arriving stockyard

Steel for hull construction is usually mild steel containing low percentage of carbon from 0.15 to 0.23 and reasonably high manganese. Minimum content of sulphur and phosphorus is desired to be less than 0.05 percent because they are result of difficulty to welding and cracks can develop during the rolling process with high sulphur. In order to control these chemical substances, the report is made to evaluate the content of each substance. All materials should have chemical contents within the range of requirement of classification society


14 SIE 2008 9:32 FAKS HP LASERJET 0322530814 st8

Huta Katowice
Walcownia Blach Grubych
BATORY Spółka z o.o.
41-506 Chorzów ul. Dyrekcyjna 6
fax (032) 77-22-575

A04/A01

ŚWIADECTWO ODBIORU NR AH /A3809/0/01/8
INSPECTION CERTIFICATE / ABNAHMEPRÜFZEUGNIS
EN 10204 : 2004
TYP/TYPE/TYPE: 3.1
WYSTAWIAJĄCY /ISUED BY/AUSSTELLER : HJ TEL/FAX (032) 77-22-777

HK WBG Batory Spółka z o.o. posiada Zintegrowany System Zarządzania wg norm: ISO 9001 ISO 14001 PN-N-18001
HK WBG Batory Spółka z o.o. has Management Integrated System according to the following standards: ISO 9001 ISO 14001 PN-N-18001
HK WBG Batory Spółka z o.o. besitzt Integrierte Management System nach: ISO 9001 ISO 14001 PN-N-18001

ZAMAWIAJĄCY - PURCHASER - BESTELLER A05
276112593 ID:2562
ARCELOR DYSTRYBUCJA POLSKA SP. Z O.O.
40-514 KATOWICE UL.CEGLANA4

ADRES WYSYŁKOWY - ADDRESS - VERSANDADRESSE A06
276112593 ID:2562
ARCELOR DYSTRYBUCJA POLSKA SP. Z O.O.
40-514 KATOWICE UL.CEGLANA4
(5)

NR I DATA ZAMÓWIENIA - ORDER No. AND DATE - Nr UND DATUM DER BESTELLUNG A07
207

Nr POTWIERDZENIA ZAMÓWIENIA - ORDER CONFIRMATION No. - AUFTRAG Nr A08
3130256/08 16.06.2008

PRZEDMIOT - PRODUCT - ERZEUGNISFORM B01
Blacha gruba gorącowalcowana

WYKONANO WG NORM I WT - TERMS OF DELIVERY AND/OR OFFICIAL REGULATIONS - LIEFERBEDINGUNGEN UND/ODER AMTLICHE VORSCHRIFTEN B03
EN10029:1991 PN 10163-2 kl.A/1 EN10025-2:2004 EN10025-2:2004 EN10029:1991 kl. A kl.

STAN DOSTAWY - CONDITION OF DELIVERY - LIEFERZUSTAND B04: +N
STAN PRÓBEK - CONDITION OF TEST-SPIECMENS PROBENZUSTAND B05: +N
MATERIAŁ OZNACZONO - MATERIAL MARKING - DAS MATERIAL WURDE BEZEICHNET B06: znak huty, gatunek, nr wytopu, nr próby, znak KJ
HJ-27

POZ. POS. POS. (B09)	MARKA-QUALITY-STAHLSORTE (B02)	WYMIAR DIMENSIONS ABMESSUNG	WYTOP Nr HEAT No. SCHMELZE Nr (B08)	SPOSÓB WYTOPU PROCESS ERSCHMELZUNGS-VERFAREN (C70)	SZTUK PIECES STÜCK (B10)	WAGA TEORET. THEOR. WEIGHT THEOR. GEWICHT kg (B14)	PRÓBA Nr TEST No. PROBE Nr
1	S355J2+N	12.0 * 2500 * 12000	822245	CC	7	19782	A3809

225
Nr blach:D,E,F,L,M,N,P,

SKŁAD CHEMICZNY - CHEMICAL COMPOSITION - CHEMISCHE ZUSAMMENSETZUNG C71+C

C	Mn	Si	P	S	Cr	Ni	V	Mo	Cu	Al	W	Ti	As	N	Nb	B	Sb	CE
0.170	1.440	0.180	0.015	0.006	0.010	0.010	0.0010	0.002	0.010	0.036	-	0.0020	0.002	0.006	0.020	0.0005	-	0.4

BADANIA MECHANICZNE - MECHANICAL TESTS - MECHANISCHE PRÜFUNGEN

PRÓBA ZRYWCZA - TENSILE TEST - ZUGVERSUCH C10÷C20; TWARDOŚĆ HARDNESS HARTE C30÷C39; METODA METHOD METHODE C30; WARTOŚĆ VALUE WERTE C31/C3
PRÓBA UDARNOŚCIOWA - IMPACT TEST - KERBSCHLAGVERSUCH C40÷C4

Nr PRÓBY TEST No. PROBE Nr	MIEJSCE LOCATION LAGE (C01)	KIERUNEK DIRECTION RICHTUNG (C02)	Re MPa (C11)	Rm MPa (C12)	A5 % (C13)	KIERUNEK DIRECTION RICHTUNG (C02)	PRZY AT BEI °C (C03)	1	2	3	Σ / 3 (C43)	(C45)	TYP - TYPE - TYPE
A3809	G	T	420	548	29.5	L	-20	196	196	198	197	J	KV

PRÓBA ZGINANIA - BEND TEST - FALTVERSUCH C50÷C

CE:Z DYREKTYWĄ BUDOWLANĄ CPD 89/106/EWB.

CE 0035
Huta Katowice
Walcownia Blach Grubych
Batory Spółka z o.o.
ul. Dyrekcyjna 6
41-506 Chorzów
08
0035-CPD-A151

Uprawnienia UDT do wytwarzania blach przeznaczonych na urządzenia podlegające dozorowi technicznemu nr rej. UDT
M-09-20/03-06

INNE BADANIA - OTHER TESTS - ANDERE UNTERSUCHUNGEN C60÷C69

NINIEJSZYM POTWIERDZAMY, ŻE WYŻEJ WYMIENIONY MATERIAŁ ZOSTAŁ ZBADANY I SPEŁNIA WARUNKI POTWIERDZENIA ZAMÓWIENIA.
WE HEREBY CERTIFY, THAT THE ABOVE DESCRIBED PRODUCTS HAVE BEEN TESTED AND CONFORMS THE TERMS OF THE ORDER CONFIRMATION.
ES WARD BESTATAGT, DASS DIE LIEFERUNG GEPRUFT WURDE UND DEN VEREINBARUNGEN BEI DER BESTELLUNG ENTSPRICHT.

Z01÷Z99
G - Głowa/Top/Kopf S - Stopa/Bottom/Fuss
L - Wzdłużna/Longitudinal/Laengs T - Poprzeczna/Transvers/Quer
P - Prostokątna/Rectangula/Rechteck C - Cylindryczna/Round/Rund
LD - Konwertor/BOC E - Stal elektryczna/Electric Steel/stahl elektr
CC - Ciągłe odlewanie/Continue Casting/Stranggus SM - Siemens-Martin

KONTROLA JAKOŚCI - QUALITY CONTROL - QUALITÄTSKONTROLLE
22.07.2008
PEŁNOMOCNIK ZARZĄDU DS. KONTROLI JAKOŚCI
JAN BLASZYŃSKI

Figure 3.18 Inspection certificate for chemical substances of material arriving stockyard

Since the identification code is generally used to define each piece is intended for which the unit structure, it is convenient to store the plates and profiles in their respective ship and ship unit areas. As a rule the plates are now stacked horizontally in piles and profiles are laid horizontally in convenient batches to take them out easily without moving many items away before having it. This can be done by arranging it in order of using sequence.

It is important when employing cranes for material handling that they are adequate coverage for the full extent of the stockyard

3.6.5. Lofting

After transferring from stockyard, the plates are cut, shaped, bent or manufactured to the desired configuration which is specified by the design. Typically an automatic flame cutting process as Plasma cutting is applied to cut the plates to various shapes. These shapes may be then welded together to form I and T beams and other structural members for units or subassemblies at the next steps.

The lofting office is responsible for preparing detailed working structural, general arrangement and outfit drawings for production. For numerically controlled profiling machines, the steel piece parts can be nested in order to achieve the most economical plate which can be handled by the machine with minimum wastage.

Draftsman at the drawing stage has to define individual piece parts are abstracted for steel requisitioning and stored and then bring back to the screen for interactive nesting performance. There are many software for nesting plates by using drawing tool on the graphics screen to optimise the productivity of marking and cutting lines as minimum as possible. This task can be manual or automatic but the order in which steel parts are to be marked and cut have to carefully consider and logically organize to reduce wasted plates and movement of burning head tool machines. After checking for errors, the cutting sequence is saved as burning instructions file or NC tape (nest cutting tape) on which is recorded the co-ordinate points of a plate profile and subsequently sent to Plasma cutting machine. The loftsman set up the NC tape read into the director which produces command signals to the servo-mechanism of the Plasma cutting machine. These machines may be provided with accessories for marking plates.

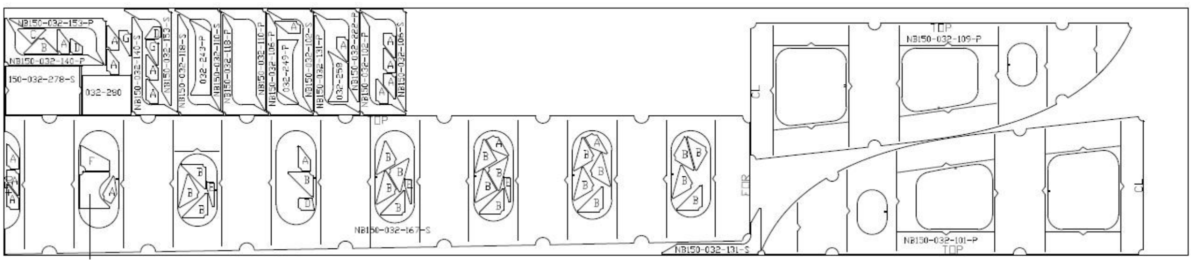
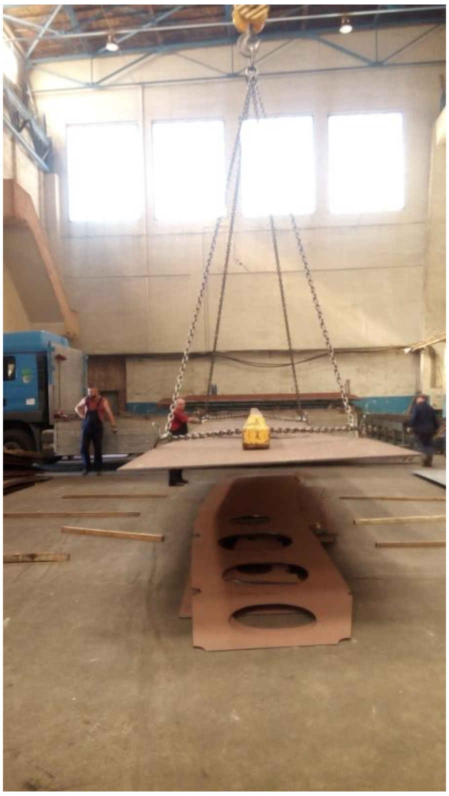


Figure 3.19 Nest cutting tape



The overhead electric cranes having capacities from 5 to 15 tonnes may be installed to transport plates and sections throughout the workshop.

Figure 3.20 Overhead crane in workshop

Cutting is achieved by the use of an oxy-fuel flame or plasma-arcs with controlling of using the CAD/CAM systems available.

Advantages of Plasma cutting

- Applicable for a large range of thickness
- Excellent quality of cutting edges
- No changing of metallurgic characteristics
- Possibility to shape chamfers at the same time
- Very narrow cutting jet
- High speed of cutting

  2-2.5 m/min for a 12 mm steel plate

  0.5-0.7 m/min for a 40 mm steel plate

Plate specification:

- plate length over 12m
- plate thickness up to 150mm
- plate width up to 3,2m

Figure 3.21 Plasma cutting machine

Shipyard is able to construct every panels creating block unit with various plate thicknesses. With plasma cutting, steel plates are prevented by corrosion and over heat effect by small cutting area that reduce strength of steel plate. In addition, numerically controlled machines will save wasted material and achieve high precise profile plates.

One of Plasma cutting machine is to make templates for construction and checking curve plates and section by using paint head tool instead of flame one to mark the lines into wooden plane subsequently cut it and form of 2D or 3D templates.

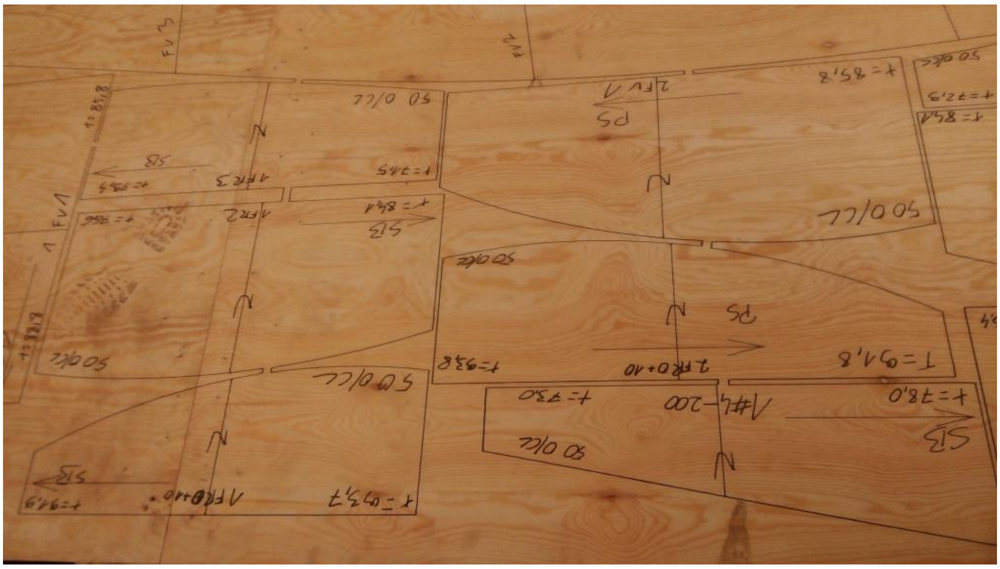


Figure 3.22 2D templates

3D models are used to be better understanding drawing and easily check to ensure sufficient elements for unit, especially for sophisticated structure.

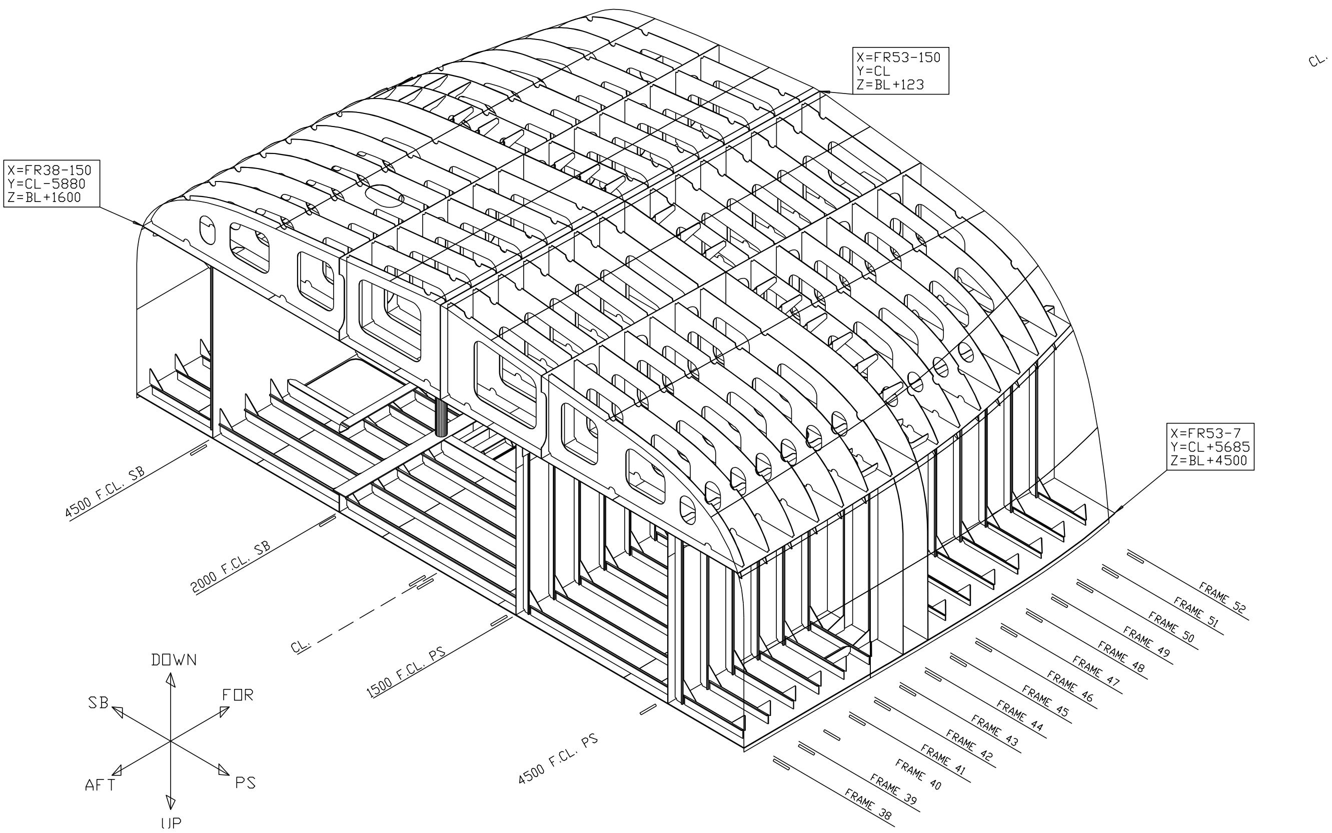
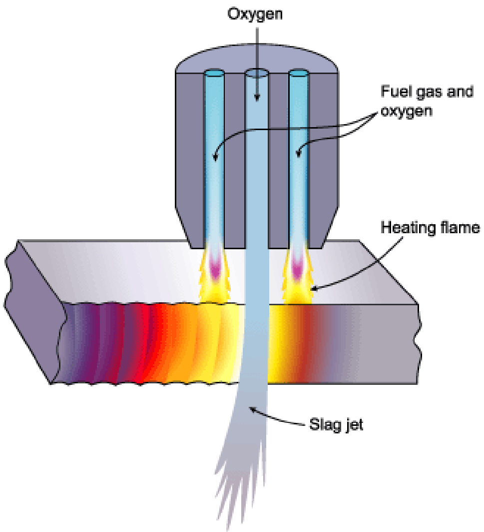


Figure 3.23 3D view.

3.6.6. Cutting

The oxy-fuel process is the most widely used thermal cutting process because it provides some advantages.

- Low cost equipment
- Basic equipment suitable for cutting, gouging and other jobs such as welding and heating
- Portable, suitable for site work
- Manual and mechanised operations
- Mild and low alloy steels (but not aluminium or stainless steel)
- Wide range of thickness (typically from 1mm to 1000mm)



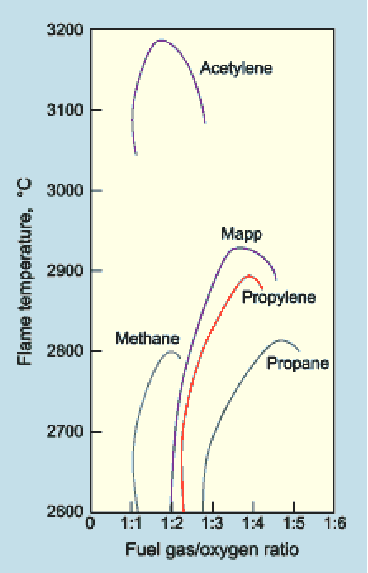
The cutting process is described basically of a mixture of oxygen and the fuel gas that is used to preheat the metal to its 'ignition' temperature (for steel is 700°C - 900°C - bright red heat) but well below its melting point. A jet of pure oxygen is then directed into the preheated area introducing a vigorous exothermic chemical reaction between the oxygen and the metal to form iron oxide or slag. After that the oxygen jet blows away the slag allowing the jet to pierce through the material and continue to cut through the material.

Figure 3.24 Principle of oxy-fuel cutting process

There are four basic requirements for oxy-fuel cutting:

- the ignition temperature of the material must be lower than its melting point otherwise the material would melt and flow away before cutting could take place
- the oxide melting point must be lower than that of the surrounding material so that it can be mechanically blown away by the oxygen jet
- the oxidation reaction between the oxygen jet and the metal must be sufficient to maintain the ignition temperature
- a minimum of gaseous reaction products should be produced so as not to dilute the cutting oxygen

Here, the maximise performance of the process application in terms of cut quality and cutting speed highly depends on the choice of fuel gas and nozzle design.



The choice of fuel gas is taken into consideration of cost, performance, ease of use and whether it is a manual or mechanised operation.

The five most commonly used fuel gases are acetylene, propane, MAPP (methylacetylene-propadiene), propylene and natural gas. The relative performance of the fuel gases in terms of pierce time, cutting speed and cut edge quality, is determined by the flame temperature and heat distribution within the inner and out flame cones. Acetylene produces the highest flame temperature of all the fuel gases and also most common practice cutting process in shipbuilding.

Figure 3.25 Comparison of different fuel gases

The diverse uses of acetylene flame can achieve not only cutting but also welding and other application as below:

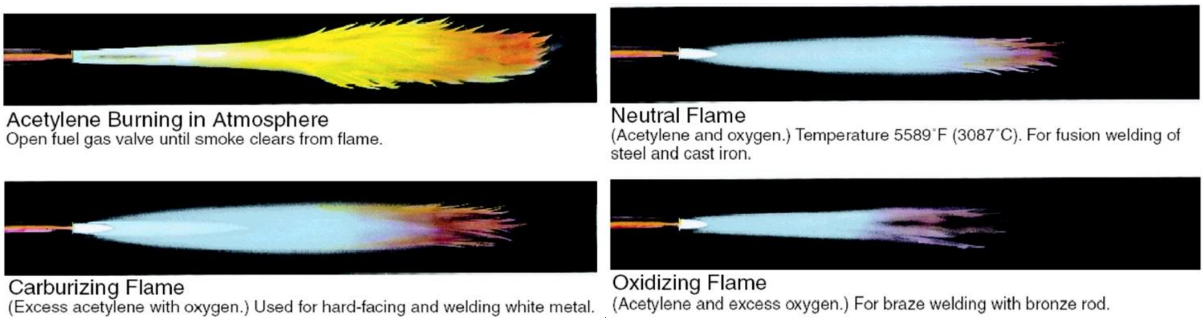


Figure 3.26 Types of acetylene flame

The cutting speed and cut edge quality are primarily accomplished by the purity of the oxygen stream. Consequently, cutting torch design plays a significant role in protecting the oxygen stream from air entrainment.

The cutting torch can be either nozzle mix or injector. In the nozzle mix torch, the fuel gas and pre-heat oxygen are mixed in the nozzle. In the injector torch, the pre-heat gases mix either in the body of the torch, within the gas delivery tubes, or within the head of the torch. Injector torches are better because of enhancing the higher pressure of oxygen to pull the fuel into the torch. This allows the torch to be used at low fuel gas pressures or with large pressure drops such as those experienced through long hose lengths.

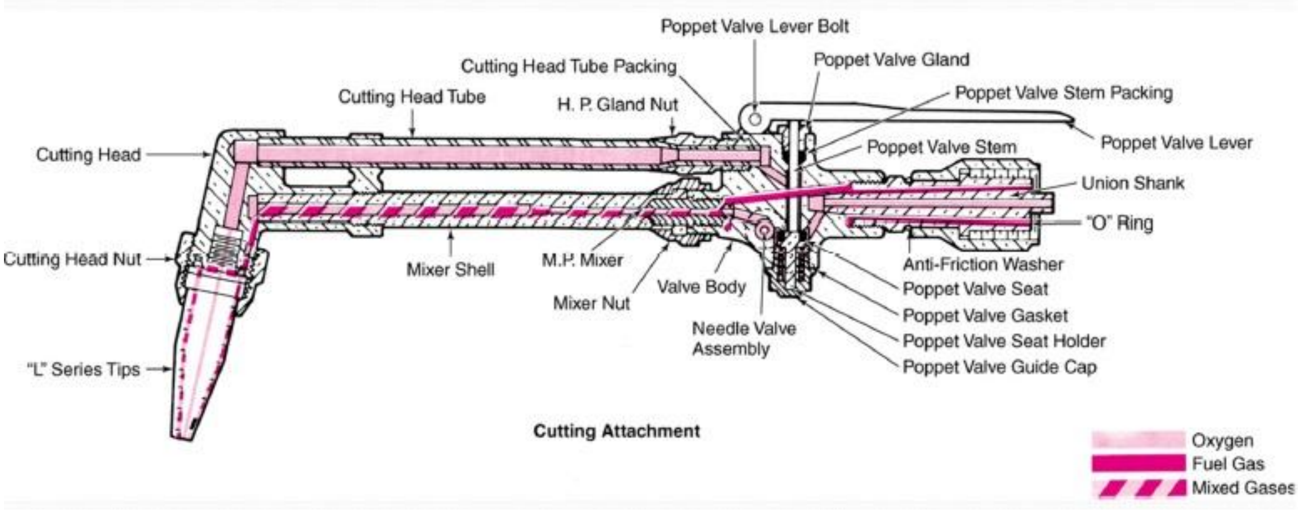


Figure 3.27 The injector torch

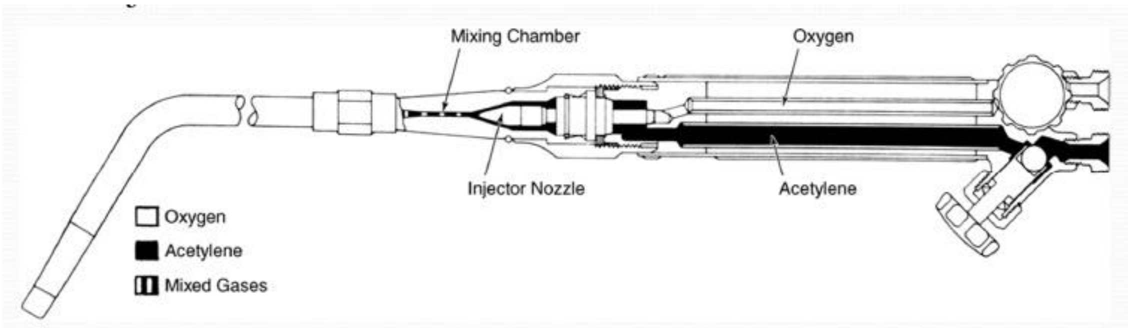


Figure 3.28 The nozzle mix torch

Best practice to ensure adequate quality of the cut surface is also included.

The ideal cutting conditions are normally expected to produce the square edge, smooth surface cut at the highest cutting speed. The settings for the material thickness and the cutting speed are the main criteria for process:

- nozzle distance - too high or too low will disturb oxygen flow
- preheat flame - too high a flow can cause top edge melting
- cutting oxygen - too low a flow can cause poor slag removal - too high a flow can result in poor cut finish

There are several typical appearances of cut surface quality for manual cutting are discussed below:

Figure 3.29 Ideal Cut Profile

Square edge, smooth cut surface, underside free of slag, small drag lines

Figure 3.30 Cutting Too Fast

Coarse drag lines at angle to surface with excessive amount of slag are sticked to bottom edge of plate because of oxygen jet trailing with insufficient oxygen reaching bottom of the cut

Figure 3.31 Too high nozzle to plate distance

Uneven cut surface with heavy melting of top edge, coarse drag lines at bottom cut surface because preheat is not focused on plate surface, oxygen jet easily disturbed

Figure 3.32 Too High Oxygen Flow

Excessive slag remains on cut face, local gouging, excessive top edge melting because of turbulence between the preheat flame and the cutting jet

The process can be used for a wide range of applications from manual rough severing and scrap cutting to precision contour cutting in fully automated systems.

3.6.7. Bending

A number of the methods are used for forming plates into the required shapes so as to fit plates to the curve of the hull.

3.6.7.1. Plate rolls

Heavy duty bending rolls operated hydraulically are used for rolling shell plates to obtain curvature. Two lower rolls are rotated in the same direction so that the plate is fed between

them and a slightly larger diameter top roll which runs slower. Either or both ends of the top roll may be adjusted for height and the two lower rolls have adjustable centres.
With big and modern bending rolls, plates up to 45 mm thick may be treated and rolled plates to a half circle. These large rolls are also provided with accessories to allow them to perform heavy flanging work with the pressure exerted by the upper beam.

Figure 3.33 Bending roll machines

3.6.7.2. Heat line bending

For the sophisticated shape of steel plate of force and aft parts of the ship the ‘heat-line’ bending procedure is a widely used technique to achieve complicated curvature.
It is, however, a process that until recently remains constraints of relying on highly skilled personnel and not guarantee constant accuracy of shapes formed.
The process is done by heat which is applied in a line to the surface of a plate by a flame torch, and then immediate cooling is undertaken by air or water.
The narrow heated line of material is prevented from expanding in the direction of the plate surface by the large mass of cold plate, and therefore expands outwards perpendicular to the plate surface. On cooling contraction will take place in the direction of the plate surface, causing the plate to become concave on the side to which heat was applied. An experienced operator is able to make a pattern of such heat lines on a plate producing controlled distortion to obtain a required shape. Heat line bending can be more time consuming than using rolls or presses but it has an advantage in that the plate holds its form more accurately when stiffening and other members are added later in the fabrication process. This is an important consideration since shape inaccuracy can be critical at the erection stage in terms of lost production time.

Figure 3.34 Heat line bending method

3.6.7.3. Cold frame bending

It is now almost universal practice to cold bend ship frames using commercially available machines for this purpose. The frames are progressively bent by application of a horizontal ram whilst the frame is held by gripping levers . Any type of rolled section can be bent in some machines with a limitation on the size of section.

Obtaining the correct frame curvature can be achieved by the 'inverse curve' method or numerical control. With the 'inverse curve' method the inverse curve information can be determined for each frame by the loftsman using a CAD/CAM system. The inverse curve is drawn in chalk on the straight frame and the frame bent until the chalk line becomes straight on the curved frame . A hydraulic cold frame bending machine can be controlled by numerical control tapes prepared in a similar manner to the numerically controlled flame profilers, the frame line being initially defined from the computer stored faired hull.

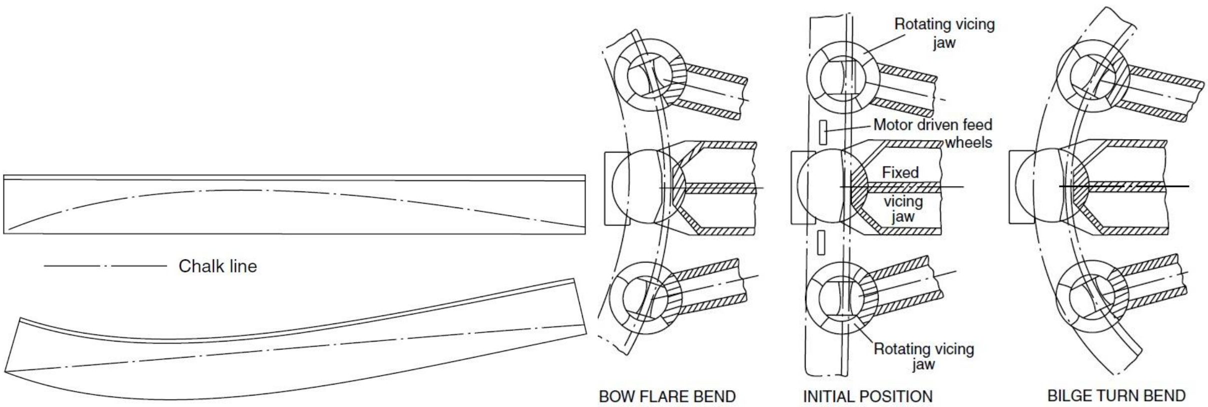


Figure 3.35 Cold frame bending principle

Figure 3.36 Practical bending work

3.6.8. Welding

3.6.8.1. General literature of fusion welding

Steel is an excellent material for shipbuilding purposes, and in all welding applications the choice of welding electrode is critical. A weld having equivalent strength characteristics to that of the base metal is desired as a target of welding process. Since micro flaws are possible to happen in production welding, welds are often designed and welding electrodes selected to provide welds with properties in excess of those of the base metal.

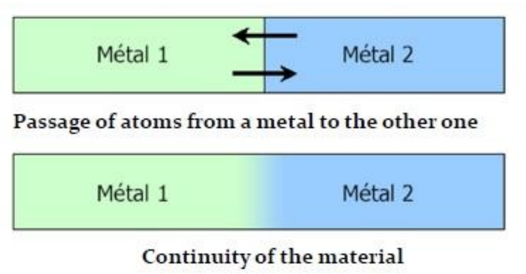


Figure 3.37 Fusion welding methodology

Shipyard welding processes, mainly fusion welding, is the most universal welding process performed at almost every location in the shipyard. The welding is an assembly process that involves joining metals by bringing adjoining surfaces to extremely high temperatures to be fused together with a molten filler material. The source for heating is usually created by an electric arc or a gas flame. The selection of the type of welding process based on customer specifications, production rates and a variety of operating constraints including government regulations.

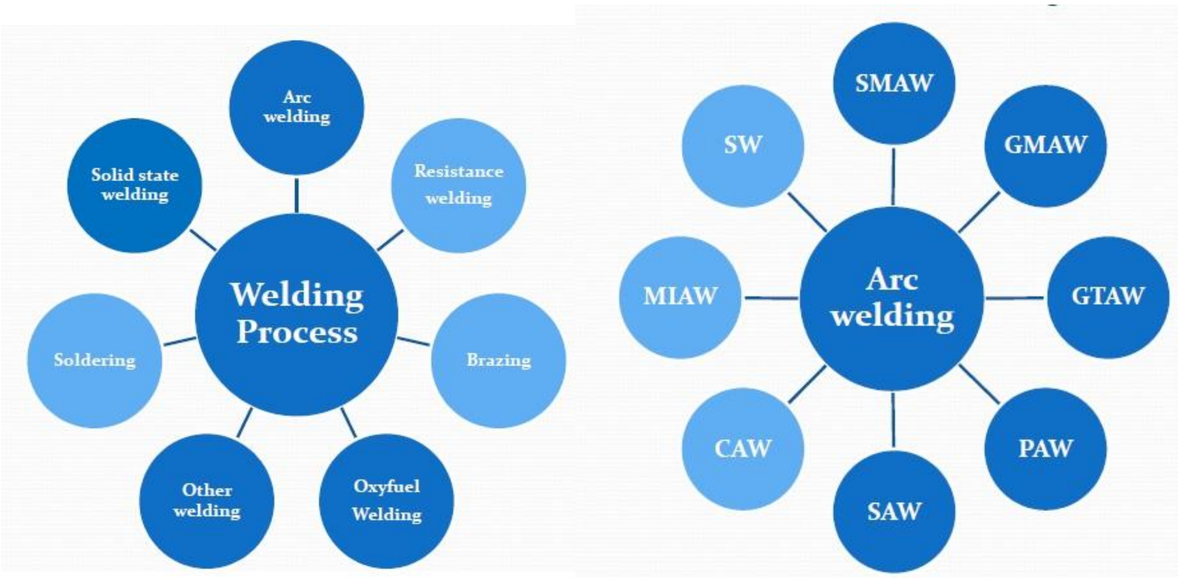


Figure 3.38 Class of welding process

Arc shielding is an important factor for the fusion-welding processes to protect the weld pool. The temperature of the weld pool is substantially higher than the adjoining metal's melting point. At extremely high temperatures, a reaction with oxygen and nitrogen in the atmosphere is rapid and causes reduction on the weld strength. Hence oxygen and nitrogen from the atmosphere are trapped within the weld metal and molten rod, embrittlement of the weld area will occur. Shielding from the atmosphere is required to protect against this weld impurity and ensure weld quality. In most welding processes, shielding is generated by addition of a flux, a gas or a combination of the two. Where a flux material is used, gases generated by vaporization and chemical reaction at the electrode tip result in a combination of flux and gas shielding that protect the weld from nitrogen and oxygen entrapment.

In electric arc welding, a circuit is accomplished between the work-piece and an electrode or wire. When the electrode or wire remains a short distance away from the work-piece, a high-temperature arc is created. This arc generates sufficient heat to melt the edges of the work-piece and the tip of the electrode or wire to produce a fusion-welding system.

There are a number of electric arc welding processes which are currently used in shipbuilding. All processes require shielding of the weld area from the atmosphere. They may be subdivided into flux-shielded and gas-shielded processes.

3.6.8.2. Shielded metal arc welding (SMAW)

Flux-shielded electric arc welding processes are defined primarily by their manual or semi-automatic nature and the type of consumable electrode used. The SMAW process utilizes a consumable electrode (30.5 to 46 cm in length) with a dry flux coating, held in a holder and fed to the work-piece by the welder. The electrode consists of the solid metal filler rod core, made from either drawn or cast material covered with a sheath of metal powders. SMAW is also frequently referred to as “stick welding” and “arc welding”. The electrode metal is surrounded by flux that melts as welding progresses, covering the deposited molten metal with slag and enveloping the immediate area in an atmosphere of protective gas. Manual SMAW may be used for down hand (flat), horizontal, vertical and overhead welding. SMAW processes may also be used semi-automatically through the use of a gravity welding machine. Gravity machines use the weight of the electrode and holder to produce travel along the work-piece. SMAW is used for small space that unable to apply automatic welding machines but today is less and less used. [8]

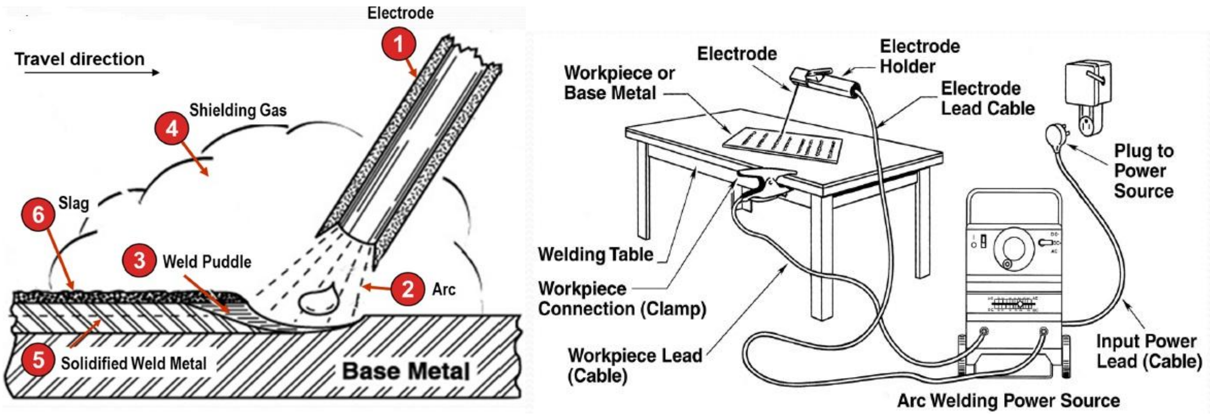


Figure 3.39 SMAW principle and equipments

Table 3.2 Characteristics of SMAW

Advantages	Disadvantages
• Low initial cost • Portable and flexible • All position capabilities • Easy to change between many base materials • Easy to use in workshops and outside (weather) • Excellent quality of the welds cords	• Lower consumable efficiency, low deposit rate • Difficult to weld very thin materials • Lower operating factor, frequent restarts • Higher operator skill required •Produce a lot of toxic smokes from the slag • High complexity (each workers need transfer and cables) • Often cables are defective

3.6.8.3. Submerged arc welding (SAW)

Submerged arc welding, another flux-shielded electric arc welding process, uses a blanket of granulated flux which is deposited on the work-piece, followed by a consumable bare metal wire electrode. Generally, the electrode serves as the filler material, although in some cases metal granules are added to the flux. The arc, submerged in the blanket of flux, melts the flux to produce a protective insulated molten shield in the weld zone. High heat concentration permits heavy weld deposits at relatively high speeds. After welding, the molten metal is protected by a layer of fused flux, which is subsequently removed and may be recovered. Submerged arc welding must be performed down hand and is ideally suited to butt welding plates together on panel lines, platen areas and erection areas. The SAW process is generally fully automatic, with equipment mounted on a moving carriage or self-propelled platform on top of the work-piece. Since the SAW process is primarily automatic, a good portion of time is spent aligning the weld joint with the machine. In addition, since the SAW arc operates under a covering of granulated flux, the fume generation rate (FGR) or fume formation rate (FFR) is low and will remain constant under various operating conditions provided that there is adequate flux cover. [8]

Table 3.3 Characteristics of SAW

Advantages	Disadvantages
• High deposition rates 45 kg/h to be compared to 5kg/h for the SMAW • High operating factors in mechanized applications • Deep weld penetration • High speed welding of thin sheet steels up to 5 m/min • Few welding fume or arc light • Practically no edge preparation is necessary • The process is suitable for both indoor and outdoor work • Distortion is less than other conventional arc welding • Single pass welds can be made in thick plates with normal equipment • No chance of spatter of weld (thanks to flux) • 50% to 90% of the flux is recoverable	• Limited to ferrous (steel or stainless steels) and some nickel based alloys • Normally limited to the 1F, 1G, and 2F positions • Normally limited to long straight seams or rotated pipes or ships • Requires relatively troublesome flux handling systems • Flux and slag residue can present a health & safety concern • Requires inter-pass and post weld slag removal

Figure 3.40 SAW practical work

3.6.8.4. Gas metal arc welding (GMAW)

The most widely use of electric arc welding comprises the gas-shielded processes is gas metal arc welding . These processes generally use bare wire electrodes with an externally supplied shielding gas which may be inert, active or a combination of the two. GMAW, also commonly referred to as metal inert gas (MIG) welding, uses a consumable, automatically fed, small-diameter wire electrode and gas shielding. GMAW is the solution for a long-sought method of being able to weld continuously without the interruption of changing electrodes. An automatic wire feeder is required. A wire spooling system provides an electrode/wire filler rate that is at a constant speed, or the speed fluctuates with a voltage sensor. At the point where the electrode meets the weld arc, argon or helium being used as the shielding gas is supplied by the welding gun. It was found that for welding steel, a combination of CO2 and/or an inert gas could be used. Often, a combination of the gases is used to optimize cost and weld quality. [8]

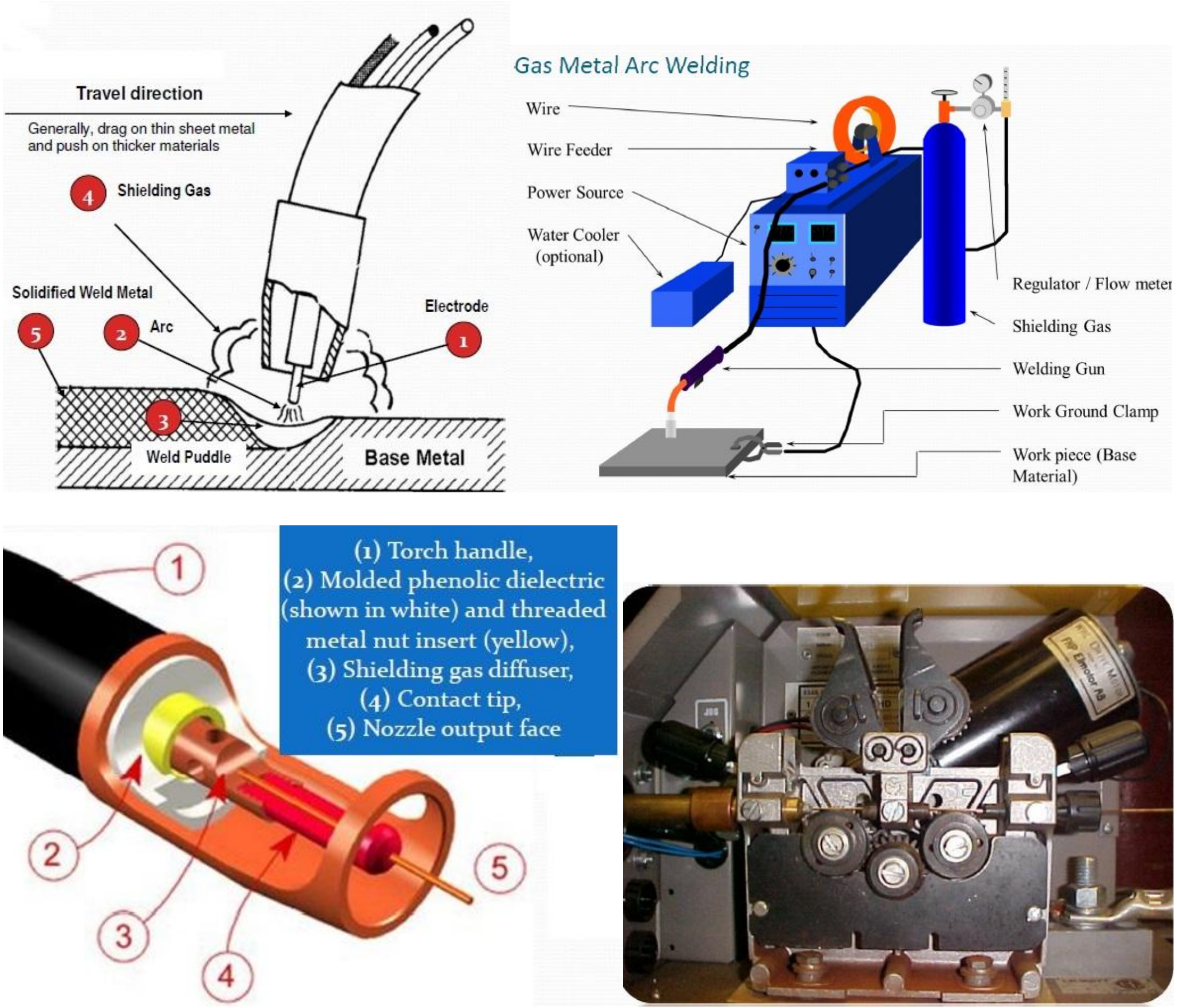


Figure 3.41 GMAW methodology and equipments

Table 3.4 Characteristics of GMAW

Advantages	Disadvantages
• High operating factor • Long weld cords without restart • Easy to learn, limited cleanup • Use on many different metals: stainless steel, mild (carbon) steel, aluminium and more • All position • Great for home use with 115V and 230V units • Great welding speed (saving time) • High penetration • No slag (no protection layer to be removed) • Wide range in thickness (0.5 – 20 mm) • Good mechanical characteristics • Good seam aspect • Semi-automated process • Lower fatigue for the welder	• Less portable with shorter gun lengths (15 foot guns) • GMAW equipment is more expensive than SMAW equipment • External shielding gas can be blown away by winds • High radiated heat • Difficult to use in out of position joints • Frequent and precise maintenance • Difficult to use in confined areas • Not easy for applications that require a large movement of the torch • Equipment heavier and more complex • Distance torch to work = 5m maximum • The time savings can be greatly reduced when the wire can remain frozen in the bath or melting solidified melt in the tube contact

3.6.8.5. Gas tungsten arc welding (GTAW)

Another type of gas-shielded welding process is gas tungsten arc welding, sometimes referred to as tungsten inert gas (TIG) welding or the trade name Heliarc, because helium was initially used as the shielding gas. The arc is generated between the work-piece and a tungsten electrode, which is not consumed. An inert gas, usually argon or helium, provides the shielding and provides for a clean, low-fume process. Also, the GTAW process arc does not transfer the filler metal, but simply melts the material and the wire, resulting in a cleaner weld. GTAW is most often employed in shipyards for welding aluminium, sheet metal and small-diameter pipes and tubes, or to deposit the first pass on a multi-pass weld in larger pipe and fitting. [8]

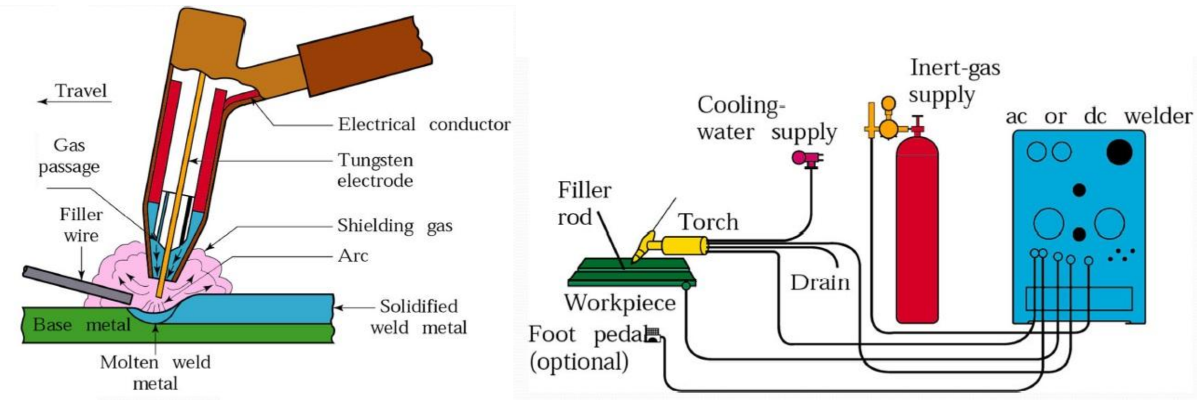


Figure 3.42 GTAW methodology and equipments

Table 3.5 Characteristics of GTAW

Advantages	Disadvantages
• Welds more metals and metal alloys than any other process such as aluminium, mild steel, titanium, stainless eel. • High quality and precision • Deep penetration • Aesthetic weld beads • No sparks or spatter • No flux or slag • No smoke or fumes	• Lower filler metal deposition rates • More user skill is required • Brighter UV rays than other processes • Slower travel speeds than other processes • Equipment costs tend to be higher than other processes • Prone to wind drafts • Metal must be clean • Possible Tungsten inclusions

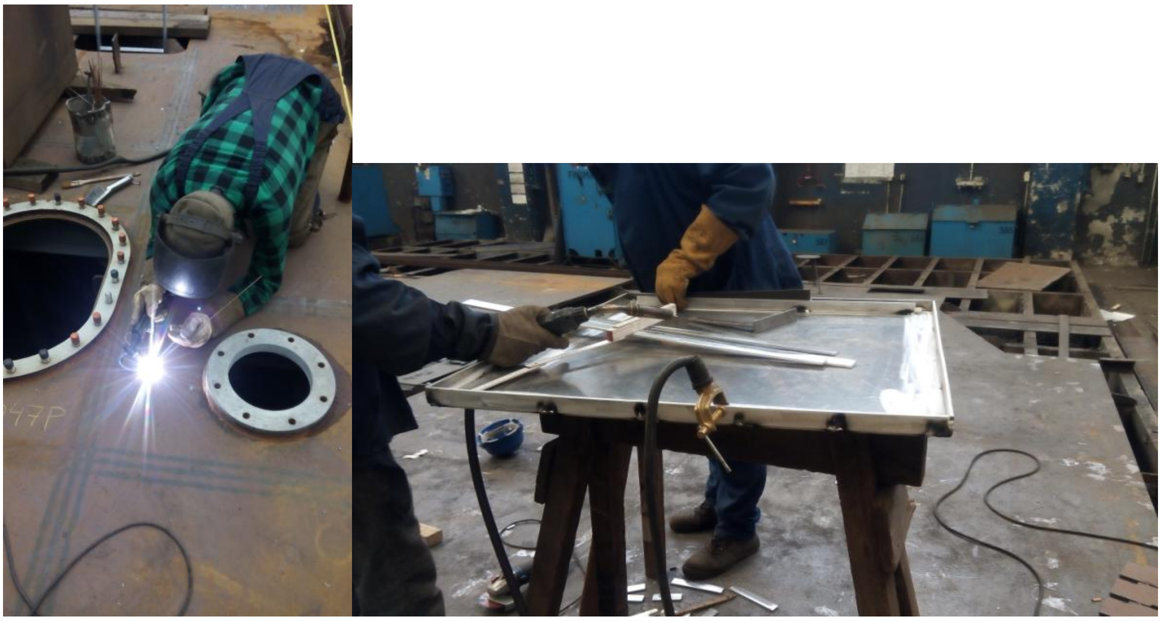


Figure 3.43 TIG applications

At fabrication shops plates and profiles are joined to construct various units and subassemblies. Automatic or manual welding or a combination of the two are widely used to mount parts together. Some most common welding processes are SAW
inert gas shielded arcs (MIG, MAG) and even non-consumable electrodes (TIG TAG)
Handling machines have jig cranes mounted on the frame which can be employed to handle the plate during the machining process. Distribution of plates in the shop may also be by means of electric powered trolleys running on rails in bays between the plate working machines.

At this juncture, outfitting job such as piping, electrical and other utility systems are assembled and integrated into the units when there are more space and convenient for handing and position for welders.

Figure 3.44 Fabrication work

3.6.8.6. Welding Procedure

For a given welding process, the statutory specified and supervised by classification society of ensuring adequate weld quality is to qualify the procedure and the skill level of the welding operator.

The most important document for practice welding process is the Welding Procedure Specification (WPS) which details the welding variables to be used to ensure a welded joint will achieve the specified levels of weld quality and mechanical properties.

The WPS is described by a number of documents, for example a record of how the weld was made, NDE, mechanical test results which together with a welding approval record termed the WPAR (BS EN ISO 15614) or PQR (ASME).

There are a number of 'essential variables' specified which, if changed, may affect both weld quality and mechanical properties. Therefore, any change in the essentials variables will not be validated the welding procedure and will require a new approval test to be taken. The essential variables are presented in the relevant specification and include material type, welding process, thickness range and sometimes welding position.

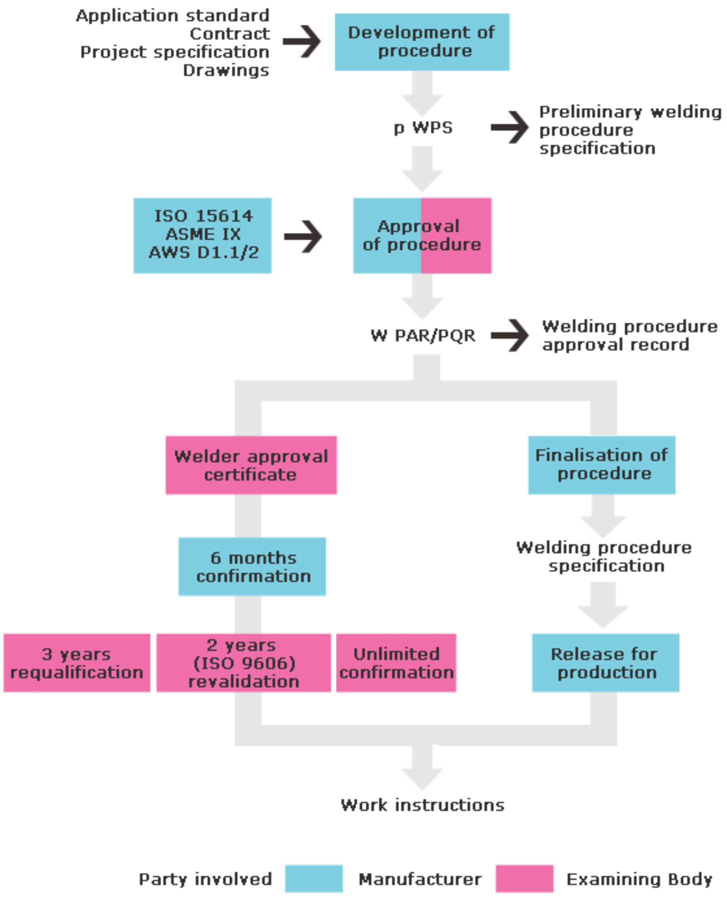


Figure 3.45 Stages in welding procedure and welding approval. [9]

The most common method to receive approval is to undergo an approval test as described in BS EN ISO 15614-1 (steels) and 15614-2 (aluminium and its alloys).

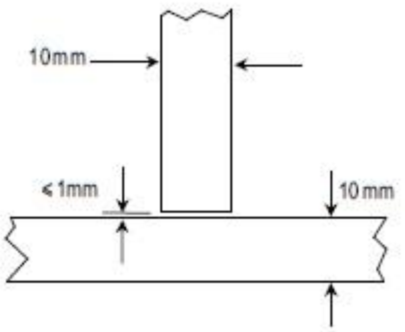
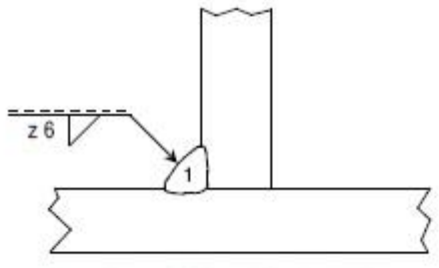
The welding department of shipyard initially drafts a preliminary welding procedure (pWPS) which is used by one of the shipyard welders to prove that it is capable of producing a welded joint to the specified levels of weld quality and mechanical properties. The welding procedure approval record (WPAR) is a record of this weld. If the WPAR is approved by the Examiner, it is used to finalise one or more WPSs which is the basis for the Work Instructions given to the welder.

preliminary Welding Procedure Specification (pWPS)

Location: Workshop
Manufacturer's Welding Procedure Specification No: 01p
WPQR: N/A*
Manufacturer: To be confirmed

Welder's Name: To be confirmed
Welding Process: 135 (MAG)
Joint Type: Fillet Weld (Single or Double Sided)

Method of Preparation and Cleaning:
Thermal cut and / or grinding, wire brush and degrease if required
Parent Material Designation:
BS EN 10025-2: S355 J2 (Max CEV = 0.45)
Material Thickness: 10mm
Outside Diameter: N/A
Welding Position: PB (Horizontal - Vertical)

Joint Design	Welding Sequence
	

Dimension z = Fillet weld leg length in mm

Welding Details:

Run	Process	Size of Filler Metal Ø mm	Current A	Voltage V	Type of Current/ Polarity	Wire Feed Speed m/min	Travel Speed mm/min	Heat Input kJ/mm
1	135 (MAG)	1.2	270 - 290	29 - 31	DC +ve	7.5 - 8.3	320 - 340	1.1 - 1.3

Filler Metal Classification & Trade Name	BS EN ISO 14341: G3 Si1 (Trade name to be confirmed)
Any Special Baking or Drying	Stored in accordance with manufacturers recommendations
Gas/Flux: - Shielding / Backing	Argon / 20% CO_2 / 2% O_2
Shielding Gas Flow Rate	15 - 18 L/min
Tungsten Electrode Type / Size	N/A
Details of Back Gouging / Backing	N/A
Preheat Temperature	0°C Minimum
Interpass Temperature	N/A
Post-Weld Heat Treatment and / or Ageing	N/A
Time, Temperature, Method	N/A
Heating & Cooling Rates	N/A

Other Information: Nozzle diameter = 16mm.
Weld finish to be left as-welded.

For Manufacturer:
RWC's Signature

For Examiner / Examining Body:
To be confirmed

It is noticeable that the welder carrying out a satisfactory welding procedure approval test is approved for the appropriate range of approval given in the relevant standard (BS EN ISO 9606).

The following options for procedure approval are also possible:

- Welding procedure test (BS EN ISO 15614)
- Approved welding consumable (BS EN ISO 15610)
- Previous welding experience (BS EN ISO 15611)
- Standard welding procedure (BS EN ISO 15612)
- Pre-production welding test (BS EN ISO 15613)

The conventional procedure test (as specified in BS EN ISO 15614) does not always require to be performed to have approval. However alternative methods have certain limits of application regarding to welding processes, materials and consumables as specified in the appropriate application standard or contract agreement.

The welding procedure test method of approval is often a mandatory requirement of the Application Standard. Without it, the contracting parties can agree to use one of the alternative methods. For instance, a welding procedure specification can be approved in accordance with the requirements of BS EN ISO 15611 on condition that the shipyard can prove, with equivalent documentation, that the type of joint has previously been welded satisfactorily.

CONFÉDÉRATION EUROPÉENNE CEOC D'ORGANISMES DE CONTRÔLE

Appointed Notified Body under the PED № 0037

ZURICH

UKAS INSPECTION N°006

SAFed SAFETY ASSESSMENT FEDERATION

E1

1 WELDING PROCEDURE APPROVAL TEST CERTIFICATE

2 Page 1 of 3

3	*Manufacturer's Welding Procedure*	*Inspecting Authority* ZC/WP/110662
4	*Reference No.* ASLR/AUTO/001	*Reference No.* SS42527650/1
5	*Manufacturer:* A S L R FABRICATIONS LTD	
6	*Address:* OPAL WAY STONE BUSINESS PARK STONE STAFFS ST150SS	
7	*Code / Testing Standard:*	BS EN ISO 15614-1 2004+A1 2008
8	*Date of Welding:*	07/09/2011
9	*RANGE OF QUALIFICATION*	
10	*Welding Process:*	FULLY MECH MAG(135)
11	*Joint Type:*	PARTIAL PENETRATION BRANCH WELD, FILLET WELD
12	*Parent Metal Groups .Sub Groups:*	1.1 Re<=195N/mm²
13	*Parent Metal Thickness (mm):*	3mm-5.2mm WELDED TO 3mm-5.85mm
	Weld Metal Thickness (mm):	1.4mm-2.6mm
	Throat Thickness (mm):	NO RESTRICTION(3mm-4.8mm TO 3mm-5.4mm MATL THKNS)
	Single run / Multi run:	SINGLE RUN
14	*Pipe Outside Diameter (mm):*	>=30.15mm
15	*Filler Metal Type / Designation:*	EN ISO 14343-A G3 Si1
	Filler Material Make:	NO RESTRICTION
	Filler Material Size:	NO RESTRICTION
16	*Designation of Gas / Flux:*	ARGON+7%CO²+2.5%O² EN ISO 14175 M24
	Designation of Backing Gas:	NOT APPLICABLE
17	*Type of Welding Current / Polarity:*	DC+VE
	Mode of Metal Transfer:	GLOBULAR/SPRAY
	Heat Input:	NO RESTRICTION
18	*Welding Position(s):*	ALL EXCEPT VERTICAL DOWN
19	*Preheat Temperature:*	5°C MIN
	Post-Heating:	NONE
20	*Post Weld Heat Treatment:*	NONE
21	*OTHER INFORMATION*	SEE BS EN ISO 15614-1 2004+A1 2008

22 *Certified that test welds were prepared, welded and tested satisfactorily in accordance with the requirements of the code / testing standard indicated above.*

23	*Location:* BIRMINGHAM	*Date of Issue:* 15/09/2011	*Name and Signature* C DUFFELL
24			*Inspecting Authority*
25			*(CEOC Member Organization)* ZURICH ENGINEERING

ZURICH SAFed/CEOC Member Company Zurich Laboratory Services Hunt Bridge Street Bromwich B70 0DE Tel: 0121 520 5868

Übersetzung des vorgedrucklen Formblatt-Textes auf der Rückseite | Translation of printed test on the reverse side | Traduction des rubiques imprimées au verso

Note: This is a Welding Procedure Qualification Record and is applicable to the named manufacturer alone. This qualification is not a Standard Welding Procedure and may not be reproduced in whole or part and used as such.

Figure 3.46 Welding procedure approval test certificate

3.6.9. Welder approval

The welder approval test is conducted to prove that the welder has the necessary skill to produce a satisfactory weld under the conditions used in production as detailed in the approved WPS or Work Instruction. As a general rule, the test piece approves the welder not only for the conditions used in the test but also for all joints which are considered easier to weld. As the welder's approval test is made on a test piece which is representative of the joint to be welded, it is independent of the type of construction. The precise conditions, called 'essential variables', must be specified in the approval test, for example material type, welding process, joint type, dimension and welding position. The extent of approval is not necessarily restricted to the conditions used for the test but covers a group of similar materials or a range of situations which are considered easier to weld.

In BS EN ISO 9606, the certificate of approval testing is issued under the sole responsibility of the Examiner/Examining Body. The welder approval certificate remains valid subject to the requirements of the application standard. In BS EN ISO 9606, it can be CONFIRMED at six monthly intervals by the employer/welding coordinator/examiner or examining body for up to three years, depending on the route selected (see next paragraph), provided the welder has been successfully welding within the range of qualification of his/her certificate. [9]

Revalidation of the welder’s qualification can be carried out according to one of these three routes:

a) The welder shall be retested every 3 years.

b) Every 2 years, two welds made during the last 6 months of the validity period shall be tested by radiographic or ultrasonic testing or destructive testing and shall be recorded.

c) A welder's qualifications for any certificate shall be valid as long as it is confirmed as described above and provided all the following conditions are fulfilled:

- The welder is working for the same manufacturer for whom he or she qualified, and who is responsible for the manufacture of the product;
- The manufacturer's quality programme has been verified in accordance with ISO 3834-2 or ISO 3834-3;
- The manufacturer has documented that the welder has produced welds of acceptable quality based on application standards; the welds examined shall CONFIRM the following conditions: welding position(s), weld type (FW, BW), material backing (mb) or no material backing (nb).


European Scheme for the Education and Qualification of Welding and Joining Personnel

EUROPEAN WELDING FEDERATION

EOTC AGREEMENT GROUP

for Welding, Joining, Cutting and Surfacing

Having met the education and training requirements of
EWF Guideline 'European Welding Engineer' and
by examination having satisfied the requirements of the
Governing Board of the Authorised National Body

First- and Surname: Aleksandr Kantor

Date of birth: 23.09.1960

Place of birth: Charkover Gebiet, Kalügino

is hereby awarded the diploma of

EUROPEAN WELDING ENGINEER

Zertificate No.: UK-S-18059-1173-980702-03

Date: 02.07.1998

Chairman,
Board of Examiners

Dipl.-Ing. (FH) H.-G. Tuttlies

Head,
Training School

Prof. Dr.-Ing. habil. Dr. h.c. mult. P. Seyffarth

EWF Accredited National Body:
Deutscher Verband für Schweißtechnik e. V.
Training School:
Schweißtechnische Lehr- und Versuchsanstalt
Mecklenburg-Vorpommern

Scheme Administration: EOTC AG

Scheme Control: EWF

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Poland • Portugal • Romania • Slovakia • Slovenia • Spain • Sweden • Switzerland • United Kingdom


Welder's Qualification Test Certificate

No.QD2008-005

Designation(s) **EN287-1 135 P BW 1.1 S t10 PA ss nb**

WPS – Reference:WPS-QS-WB10-2 Examiner or examining body – Reference No.: BV

Welder's Name: (...)
Identification: 3702221972122XXXX
Method of identification: 05
Date and place of birth: 1972/12/25
Employer: CSSC Technical Products Ltd.

Job knowledge: not tested

	Test piece	Range of qualification
Welding process(es)	135	135, 136(m only)
Product type (plate or pipe)	P	P, T: D≥150mm
Type of weld	BW	BW,FW
Material group(s)	1.1	1.1, 1.2, 1.4
Welding consumable (Designation)	S	S,M,nm
Shielding gas Auxiliaries	EN439-M21	
Material thickness(mm)	10	3-20
Outside pipe diameter(mm)		
Welding position	PA	PA
Weld details	ss nb	ss nb,ss mb,bs

Type of qualification tests	Performed and accepted	Not tested
Visual testing	Acceptable	
Radiographic testing		√
Fracture test		√
Bend test	Acceptable	
Notch tensile test		√
Macroscopic examination		√

Name of examiner or examining body: Tan Bo, BV
Place, date and signature of examiner or examining body: Qingdao, 2008/04/24
Date of welding: 2008/02/26

Figure 3.47 Welder certificate

3.6.10. Quality control

The quality control of shipyard should works closely with supervisor of classification society, sometimes with representative of ship owner, to ensure follow exactly regulations specified by IACS for certain examinations and produce report for checking to meet requirements of ship construction. These reports are essential for both builder and buyer as final document after finishing building ship attached on the final contract when delivery. These reports prove the correct procedure of building process and its quality.

There are a number of tests have to carry out during construction process.

3.6.10.1. Measurement dimensions

The measurement dimensions take place during unit and block stages to control the shape and precise of unit parameters, for example the centre line, the length, breadth and high of block. The transverse bulkhead in unit having the greatest strength to support structure frame should be check carefully to obtain correct shape of ship and also to be easy to joint 2 units together without much remedies to fit in line. There are number of modern devices that deliver precise results also with number of advantages, for instance potable, easy to use, visible results and facilitate for examiner working in comfortable position and condition. The measurement cards are used to record the checked dimension of unit (see Annex 2)

Figure 3.48 Measurement devices

The acceptance for dimension of ship should comply with standard introduced by IACS and the tolerances have to be within the range for different parts of construction.

Hence, the table below is example for standard of IACS, detailed information can be found on No.47 Shipbuilding and Repair Quality Standard

Table 3.6 Tolerant according to IACS

Item	Standard	Limit	Remarks
Flat Plate Assembly			
Length and Breadth	± 4 mm	± 6 mm	
Distortion	± 10 mm	±20mm	
Squareness	± 5 mm	±10mm	
Deviation of interior members from plate	5 mm	10mm	
Curved plate assembly			
Length and Breadth	± 4 mm	± 8 mm	measured along the girth
Distortion	± 10 mm	± 20 mm	
Squareness	± 10 mm	± 15 mm	
Deviation of interior members from plate	5 mm	10 mm	
Flat cubic assembly			
Length and Breadth	± 4 mm	± 6 mm	
Distortion	± 10 mm	± 20 mm	
Squareness	± 5 mm	± 10 mm	
Deviation of interior members from plate	5 mm	10 mm	
Twist	± 10 mm	± 20 mm	
Deviation between upper and lower plate	± 5 mm	± 10 mm	

3.6.10.2. Tank tests

To warrantee the leakage and strength of the tanks, there are some requirements for tanks to make sure these tank having adequate stiffness and watertight. The tests rely on the function of tanks that various types of examinations are conducted. Supervisor form classification society must carry out this test or directly witness the process to strictly follow test procedures presented on regulation. The table below gives the instruction for tanks test in general ship, detailed information can be found S14 Testing Procedures of Watertight Compartments:

Table 3.7 Definition of testing processes

Hydrostatic Test: *(Leak and Structural)*	A test wherein a space is filled with a liquid to a specified head.
Hydropneumatic Test: *(Leak and Structural)*	A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air
Hose Test: *(Leak)*	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.
Air Test: *(Leak)*	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as *compressed air fillet weld tests* and *vacuum box tests*.
Compressed Air Fillet Weld Test: *(Leak)*	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.
Vacuum Box Test: *(Leak)*	A box over a joint with leak indicating solution applied on the fillet or butt welds. A vacuum is created inside the box to detect any leaks.
Ultrasonic Test: *(Leak)*	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques.
Penetration Test: *(Leak)*	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).

Table 3.8 Example of locations to be tested

Item number	Structure to be tested	Type of testing	Structural test pressure	Remarks
1	Double bottom tanks	Structural testing	The greater of the following: - head of water up to the top of overflow - head of water up to the margin line	Tank boundaries tested from at least one side
2	Tank bulkheads, deep tanks Fuel oil bunkers	Structural testing	The greater of the following: - head of water up to the top of overflow - 2.4 m head of water above highest point of tank - setting pressure of the safety relief valves, where relevant	Tank boundaries tested from at least one side
3	Double plate rudders	Leak testing		
4	Shaft tunnel clear or deep tanks	Hose testing		
5	Ballast ducts	Structural testing	Ballast ducts	

Figure 3.49 Compressed air fillet weld test

3.6.10.3. Welding control

Classification societies specify a number of non-destructive tests which is required to enable the soundness of ship welds to be assessed. The various available non-destructive testing methods may be listed as follows:

- Visual examination
- Dye penetrant
- Magnetic particle
- Radiographic
- Ultrasonic

Among these five methods, the dye penetrant and magnetic particle tests have a limited application in ship hull construction, mainly used for examining for surface cracks in stern frames and other castings. Visual, radiographic, and ultrasonic examinations are considered as the most common tests.

With the results received from these tests, some problems can be addressed as below:

- Flaw detection and evaluation
- Leak detection
- Location determination
- Dimensional measurements
- Structure and microstructure characterization
- Estimation of mechanical and physical properties
- Stress (Strain) and dynamic response measurements
- Material sorting and chemical composition determination

Much of the weld testing carried out in shipbuilding is done visually by trained inspectors who hold a certificate proved by classification society. This is the most economical and simplest method but it can be necessary in many cases as early of sub assembly stage to correct welding line immediately. In contract, this serve some drawbacks :

- Limited to the detection of surface defects
- Limited by quality resolution of the optics tool and the operator view
- Use of wide-angle leads to exaggerate the size of some defects (cavities, corrosion points)
- Surface preparation plays an important role
- Grease, oil, paint, oxide, can mask the presence of severe issues such as peaks corrosion, cracking.

Figure 3.50 Fillet gauges measures

Fillet gauges measures are recruited to check:

- The “Legs”of the weld
- Convexity (weld rounded outward)
- Concavity (weld rounded inward)
- Flatness

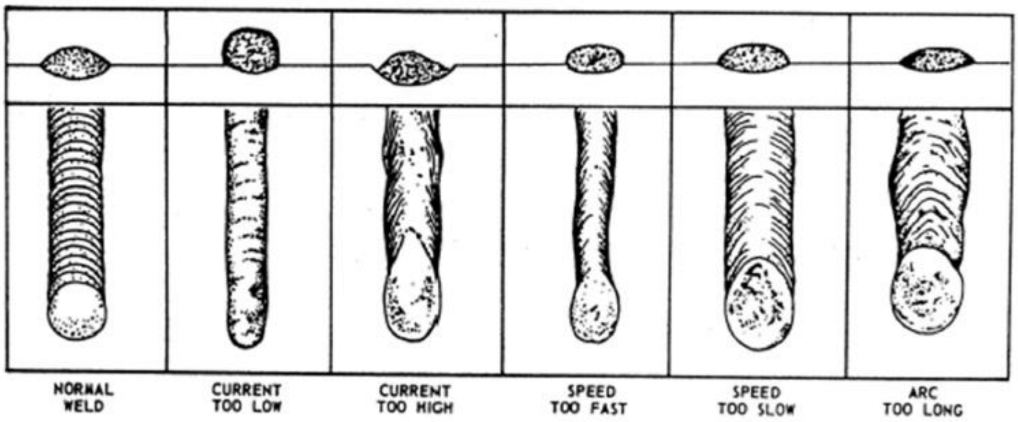
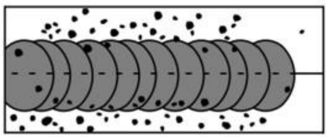


Figure 3.51 Shapes of welding lines due to current

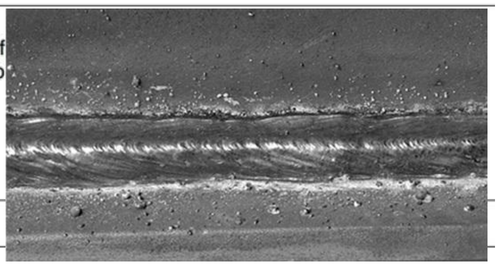
Various faults may be generated in butt and fillet welds. There are several number of factors, bad design, incorrect welding procedure, use of wrong materials, and bad workmanship. With the seriousness of the fault, the weld inspector and surveyor give a decision whether the weld is accepted or it will be cut out and rewelded.

The table below shows a series of these phenomenon:

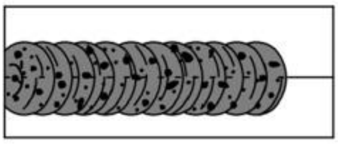
Table 3.9 Typical failures of welding



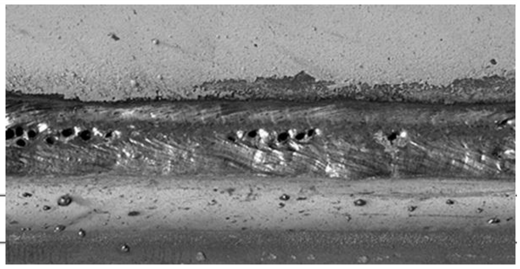
Excessive Spatter – scattering of molten metal particles that cool to solid form near weld bead.



Possible Causes	Corrective Actions
Wire feed speed too high.	Select lower wire feed speed.
Voltage too high.	Select lower voltage range.
Electrode extension (stickout) too long.	Use shorter electrode extension (stickout).
Workpiece dirty.	Remove all grease, oil, moisture, rust, paint, undercoating, and dirt from work surface before welding
Insufficient shielding gas at welding arc.	Increase flow of shielding gas at regulator/flowmeter and/or prevent drafts near welding arc.
Dirty welding wire.	Use clean, dry welding wire.
	Eliminate pickup of oil or lubricant on welding wire from feeder or liner.

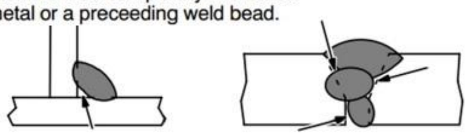


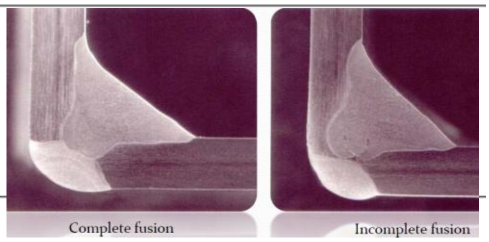
Porosity – small cavities or holes resulting from gas pockets in weld metal.



Possible Causes	Corrective Actions
Inadequate shielding gas coverage.	Check for proper gas flow rate.
	Remove spatter from gun nozzle.
	Check gas hoses for leaks.
	Eliminate drafts near welding arc.
	Place nozzle 1/4 to 1/2 in. (6-13 mm) from workpiece.
	Hold gun near bead at end of weld until molten metal solidifies.
Wrong gas.	Use welding grade shielding gas; change to different gas.
Dirty welding wire.	Use clean, dry welding wire.
	Eliminate pick up of oil or lubricant on welding wire from feeder or liner.
Workpiece dirty.	Remove all grease, oil, moisture, rust, paint, coatings, and dirt from work surface before welding.
	Use a more highly deoxidizing welding wire (contact supplier).
Welding wire extends too far out of nozzle.	Be sure welding wire extends not more than 1/2 in. (13 mm) beyond nozzle.

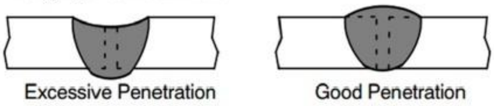
Incomplete Fusion – failure of weld metal to fuse completely with base metal or a preceeding weld bead.

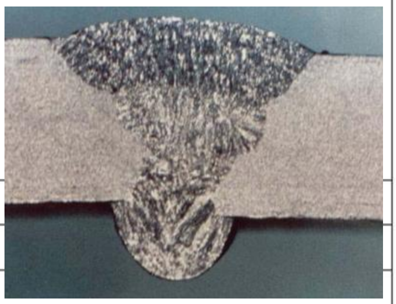




Possible Causes	Corrective Actions
Workpiece dirty.	Remove all grease, oil, moisture, rust, paint, coatings, and dirt from work surface before welding.
Insufficient heat input.	Select higher voltage range and/or adjust wire feed speed.
Improper welding technique.	Place stringer bead in proper location(s) at joint during welding.
	Adjust work angle or widen groove to access bottom during welding.
	Momentarily hold arc on groove side walls when using weaving technique.
	Keep arc on leading edge of weld puddle.
	Use correct gun angle of 0 to 15 degrees.

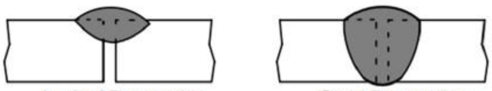
Excessive Penetration – weld metal melting through base metal and hanging underneath weld.

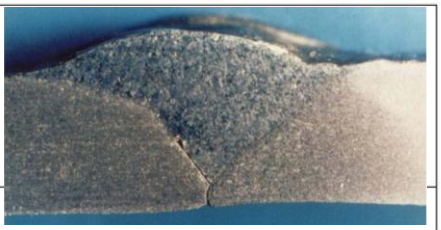




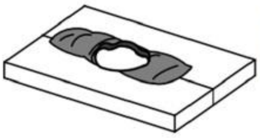
Possible Causes	Corrective Actions
Excessive heat input.	Select lower voltage range and reduce wire feed speed.
	Increase travel speed.

Lack Of Penetration – shallow fusion between weld metal and base metal.



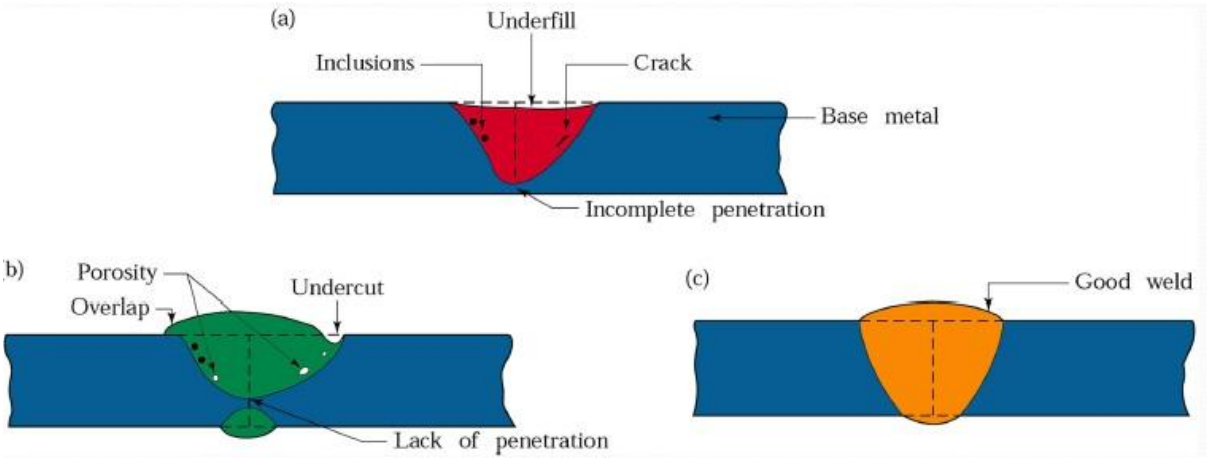


Possible Causes	Corrective Actions
Improper joint preparation.	Material too thick. Joint preparation and design must provide access to bottom of groove while maintaining proper welding wire extension and arc characteristics.
Improper weld technique.	Maintain normal gun angle of 0 to 15 degrees to achieve maximum penetration.
	Keep arc on leading edge of weld puddle.
	Be sure welding wire extends not more than 1/2 in. (13 mm) beyond nozzle.
Insufficient heat input.	Select higher wire feed speed and/or select higher voltage range.
	Reduce travel speed.



Burn-Through – weld metal melting completely through base metal resulting in holes where no metal remains.

Possible Causes	Corrective Actions
Excessive heat input.	Select lower voltage range and reduce wire feed speed.
	Increase and/or maintain steady travel speed.



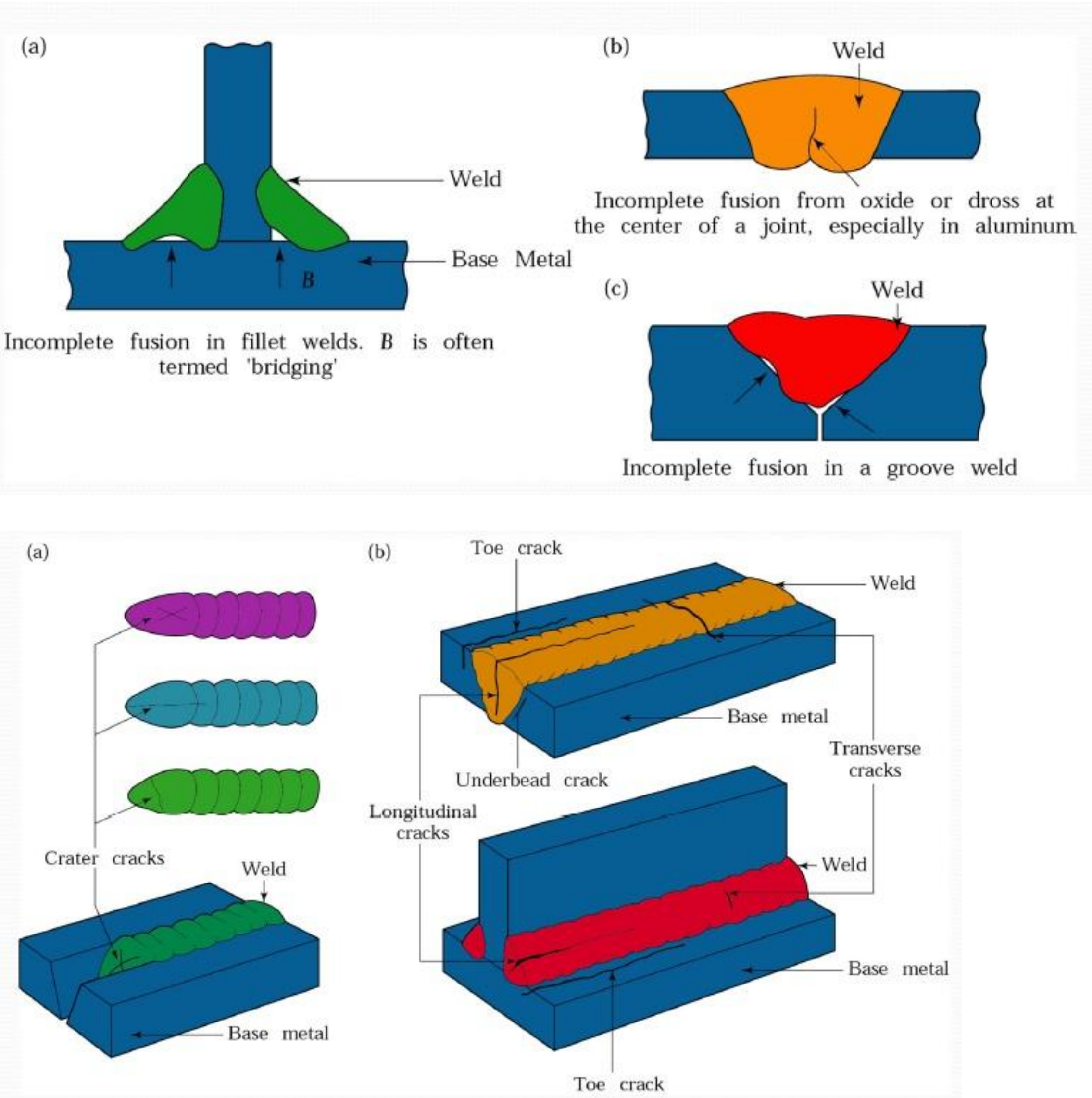


Figure 3.52 Frequent appearance of cracks

Radiographic or ultrasonic equipment are subjected to inspect the important welds in some critical parts of construction by spot checking at convenient intervals

Table 3.10 Comparison of different NDT tests

Method	Advantages	Limitations
Radiography	- Providing good quality images - Excellent spatial resolution	-Image interpretation requires a high skill - Extremely expensive - Requires a secure environment
Ultrasonic	- Possibility to detect various types of deep defects - Possibility to measure the plate thickness	- Slow method because a full scan of the part is necessary
Thermography	- Control without contact - Can be automated	-Slowness of control -Cost of the investment -Difficulty to make the diagnosis

Figure 3.53 Radiography test on join welding line in shell

3.6.11. Erection

3.6.11.1. Transport units

The units or subassemblies are usually transported by heavy truck to an open-air and lay down area where erection, or joining of assemblies, takes place to form bigger units or blocks. Constraints such as lifting capacities and dimensions that can be handled are given great consideration also the provision of breaks at natural features ensuring the blocks are self supporting and easily accessed.

Figure 3.54 Limitation of the gate dimensions and truck lifting capacity

Each block should be designed for maximum downhand welding but may be be possible to turn for this purpose. In addition, blocks are turned to effect outfit installation particularly those containing machinery flats in the aft engine room areas where pipework and other devices can be fitted on the underside of the flat with the block in the inverted position and then it is turned to install equipment above the flat floor. A block’s centre of gravity is calculated and lifting lugs so provided that these operations can be undertaken, and finally the block can be suspended for erection at the building dock or berth and drop into place in the correct plane.

Figure 3.55 Transfer unit from fabrication shop to erection area

3.6.11.2. Assembly

It is widely practice to begin in the region of the machinery spaces aft and work from the bottom upwards, and also forward and aft. The benefit of this earlier time is to give the engineers and other outfit workers early access to these confined spaces.

In erecting units stage, the correct welding sequences is significant. These are arranged to avoid excessive ‘locked in’ stresses; and overlapping frames, longitudinals, stiffeners, possible to leave unwelded across unit seams and butts until these are completed.

Figure 3.56 Starting with engine unit

Here, additional welding and fitting continue to joint units together. Further, the units and welds are subjected to quality-control inspections and testing such as radiography, ultrasonic and other non-destructive tests. Those welds found defective must be removed by grinding, arc-air grouping or chiselling and then replaced.

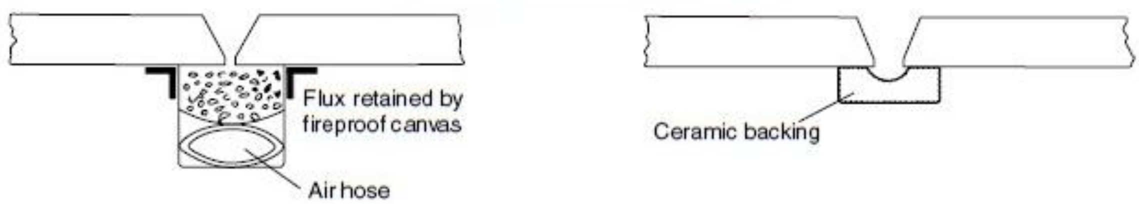


Figure 3.57 One sided welding technique

One sided welding technique is used, a back run of weld is required to ensure complete weld penetration. Permanent backing bars may conveniently be added where it is desired to weld from one side only during erection at the berth.

Superstructure blocks are fabricated separately and pre-outfitted with accommodation before erection as a complete unit. There are two outstanding advantages which aluminium alloys surpasses mild steel in use for construction of ships.

Firstly, aluminium is lighter than mild steel, 2.723 t/m^3 compared to 7.84 t/m^3 of mild steel The second advantage of aluminium is a high resistance to corrosion. Good corrosion properties can be noticed, but correct maintenance procedures and careful insulation from the adjoining steel structure are necessary.

However the high initial and fabrication costs of using aluminium alloys are main concern. For cruise ship, the recovery of capital for the higher costs construction can be compensated by an increased earning capacity from increasing passenger accommodation of the vessel the same ship dimensions

Nowadays, it is common for ship have been applied aluminium alloy superstructures. Besides the benefit from reduction in displacement, improving the transverse stability is remarkable because the reduced weight of superstructure is at a high position above the ship’s centre of gravity lead to a lower centre of gravity than that of steel structure.

The junction between aluminium alloy superstructures and steel hull promotes new process to connect 2 different metals. There are some available solution can be applied but one of the most widely use is to add a special layer of weldable material for both aluminium and steel.

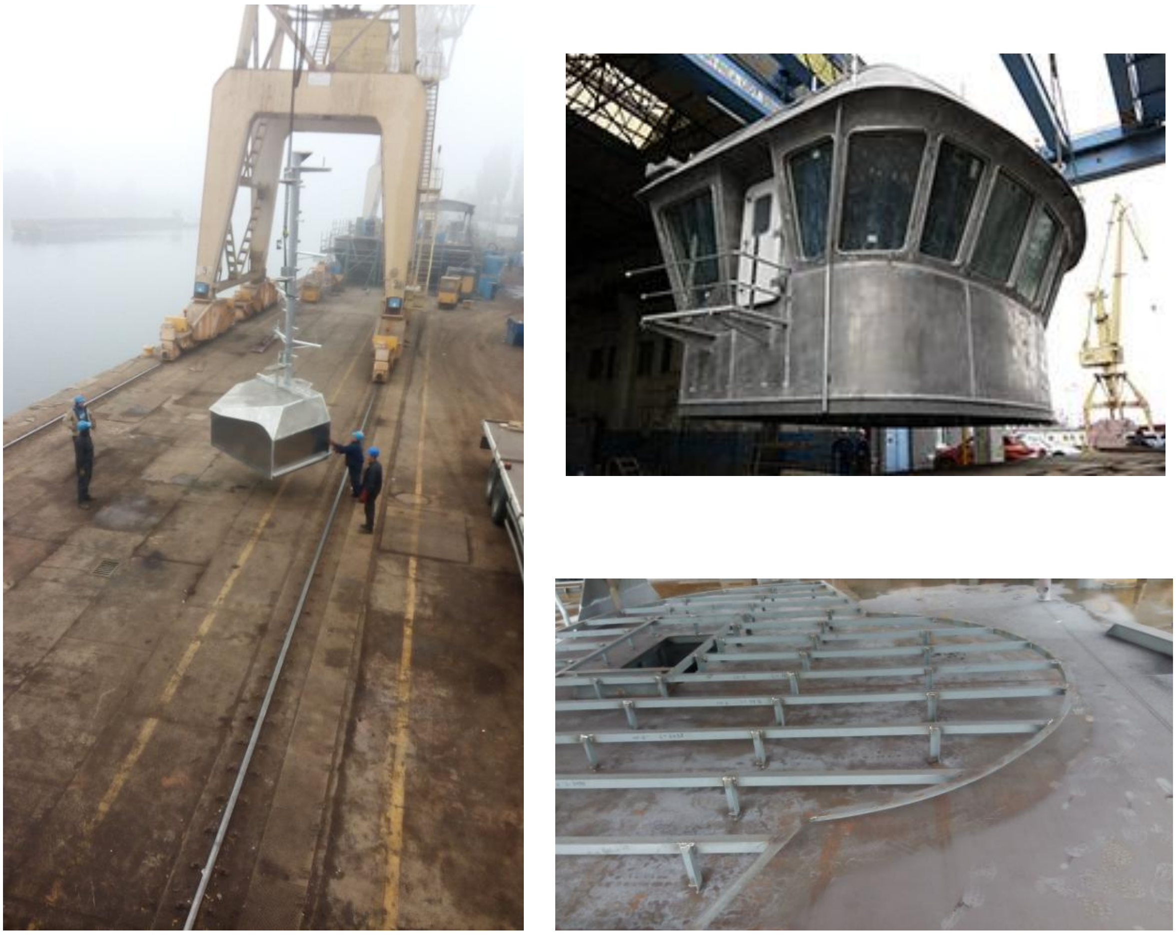


Figure 3.58 Assembly of supperstructure

Figure 3.59 Layer to joint steel and aluminium plates

3.6.11.3. Straightening

The actual distortion of a welded structure is unpredictable owing to the lack of knowledge of the degree of restraint. After many applied weld lines, the deformation have been created which make it possible for erection blocks and control shape of units. The solution how to reduce distortion can be carry out in very early stage in fabrication shop of mounting plate to plate, stiffening or unit and block construction.

Distortions are desired to treat as soon as possible owing to low cost of solution also be easy and accessible to apply. The latter remedies are, the high cost and more difficult the shipyard has to face up with.

There are commonly used of mechanical solutions thermal solutions:

For mechanical solutions, using symmetric chamfers is one of the easiest and most effective methods that can achieve small distortion.

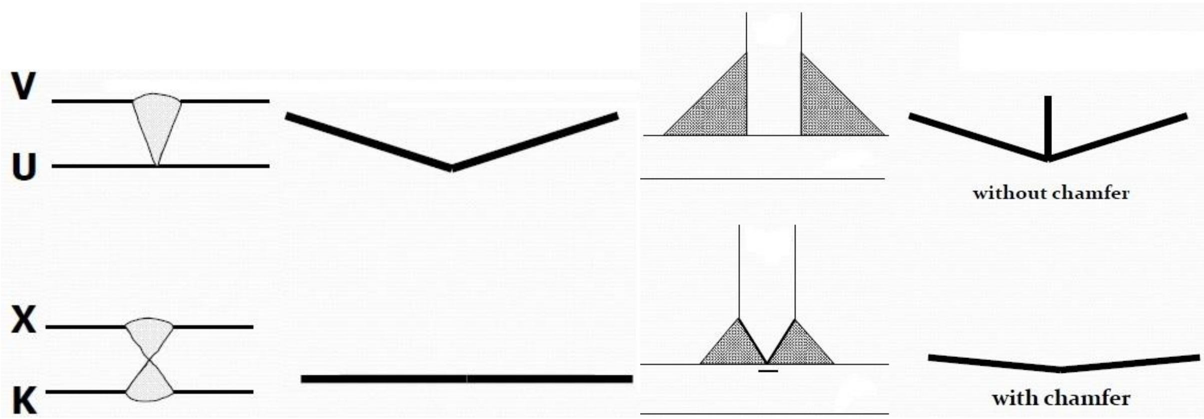


Figure 3.60 Improvement with chamfer types

Another type of mechanical solutions used extensively are mechanical press and blocking of elements, however, these may introduce residual stress inside structure.

Figure 3.61 Straightening by heavy weight

In case of complex shape of distortion, thermal solutions are carried out

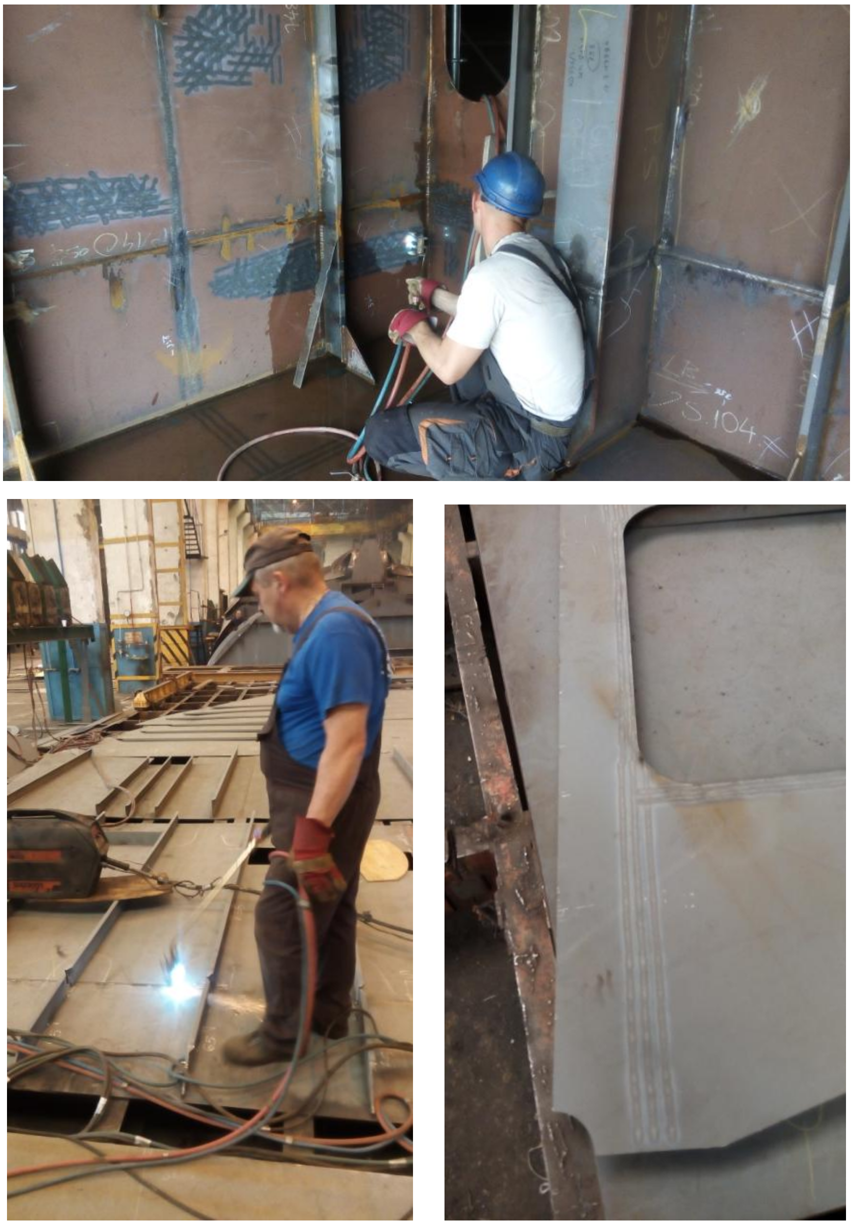


Figure 3.62 Using pre-heating reduces expansion/contraction forces

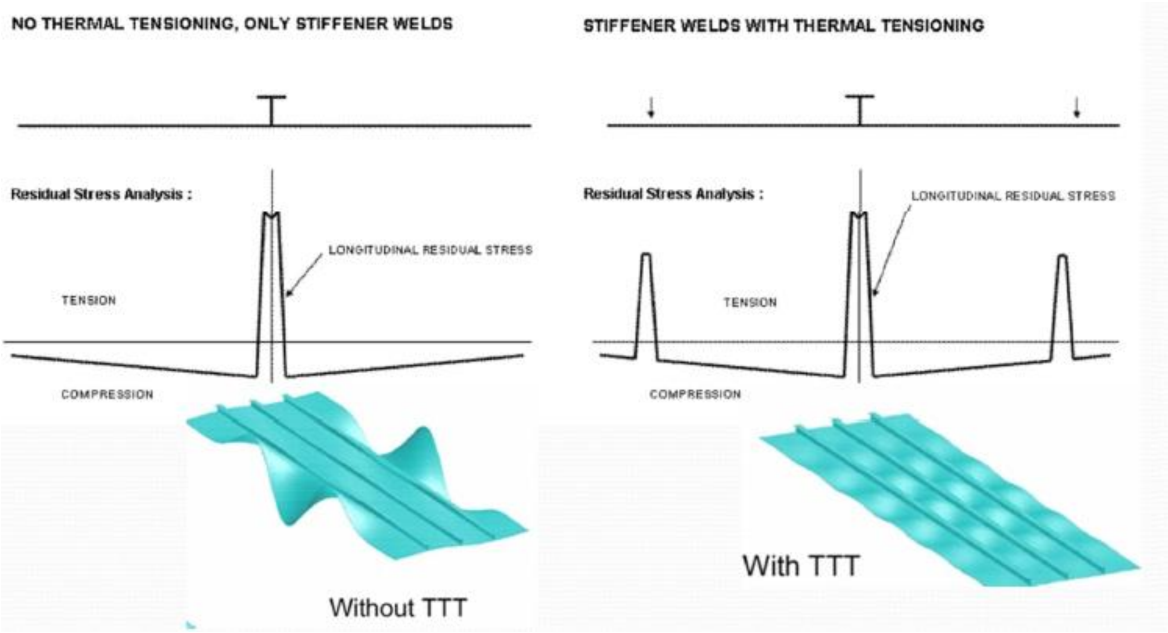


Figure 3.63 Stress analysis with and without thermal tensioning

The process is to employ high temperature from flame to heat up local area to plastification that result of the shrinkage creates a contraction, which can counteract the existing distortions.

It consumes time and greatly experienced workers who decide the place to heat and the heating time. These selections come from the experience of the worker.

If time heating too high, it will give a raise of too much change of shape and risk of metallurgical transformations as well as deterioration of mechanical properties.

If temperature exceeds 650°C, high level of residual stresses, instead of low distortions, will occur.

3.6.12. Painting

At this stage the units or blocks are abrasive blasted to ensure proper surface, and then painted.

3.6.12.1. Literature of painting

The marine offshore structures like ships, platforms, wind turbines are subjected to a wide range of exposure conditions, giving rise to a complexity and diversity of anticorrosive protection situations that need to be resolved. In particular case of ship, these include areas such as the hull, deck, superstructures, fuel tanks, ballast tanks, and others. In turn the hull presents different parts with highly specific operating conditions, going from the ship bottom (permanently immersed in sea water) to the top area (subject to alternating immersion conditions), splash area (above the water line with the ship fully loaded), and the top sides (which are practically always immersed and exposed to the atmosphere).

it is also necessary to keep the surface as smooth as possible in order to minimize drag resistance when the ship is in movement and thus reduce fuel consumption which means the need to prevent the attachment of a wide variety of marine organisms, both plants (flora) and animals (fauna).

The main methodology of painting is to exclude the steel form the corrosive environment.

Paints are made up of three main ingredients: pigment, a vehicle and a solvent.

Pigments are small particles that generally determine the colour as well as the many properties associated with the coating. Typical kinds of pigments are zinc oxide, talc, carbon, coal tar, lead, mica, aluminium and zinc dust. These give permanent colour as titanium dioxide creates white and Iron oxide generates yellow, red and black.

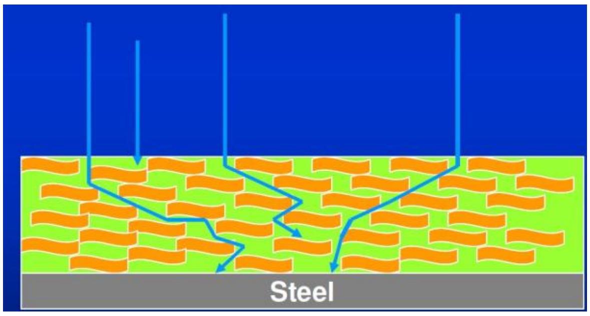


Figure 3.64 Simplified view of pigment particles held in the paint film

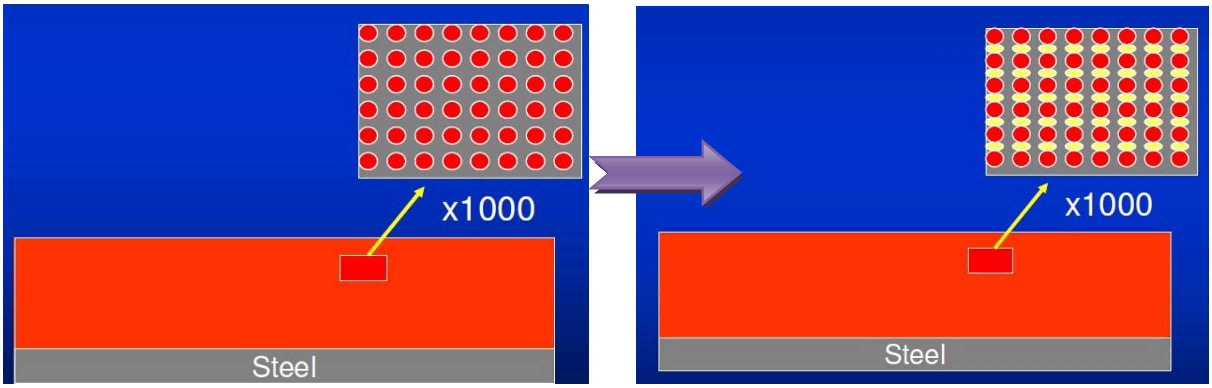


Figure 3.65 Extending pigment particles in the paint film

The vehicle can be thought of as the glue that holds the paint pigments together. Many paints are referred to by their binder type, for example epoxy, alkyd, urethane, vinyl, phenolic. The binder is also very important for determining the coating’s performance characteristics such as flexibility, chemical resistance, durability, finish.

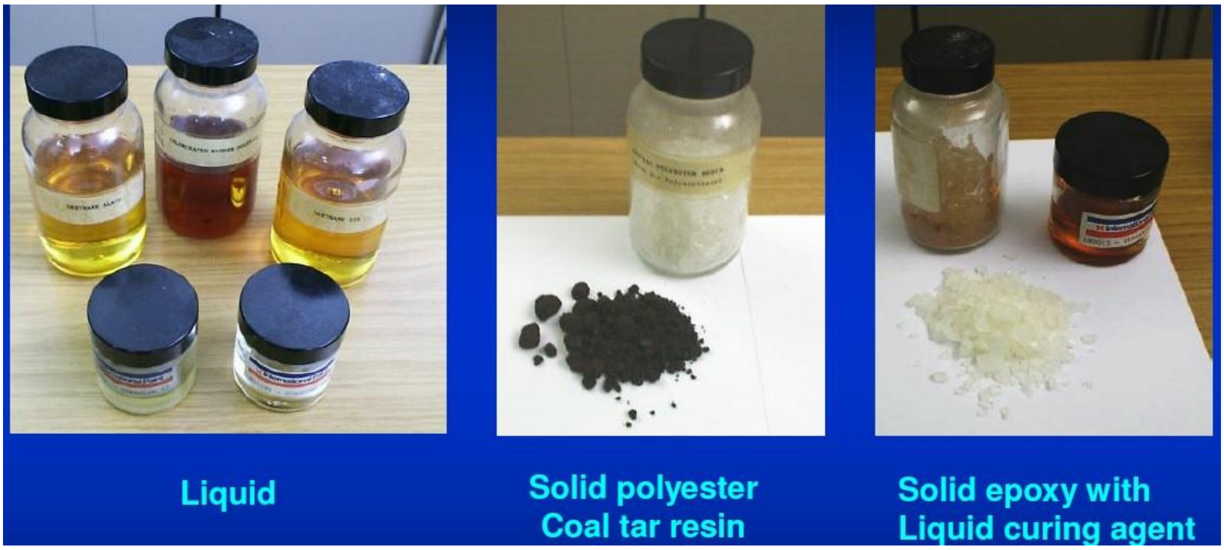


Figure 3.66 Binder types

The solvent is added to thin the paint and allow for flowing application to surfaces. The solvent portion of the paint evaporates when the paint dries. Some typical solvents include acetone, mineral spirits, xylene, methyl ethyl ketone and water.

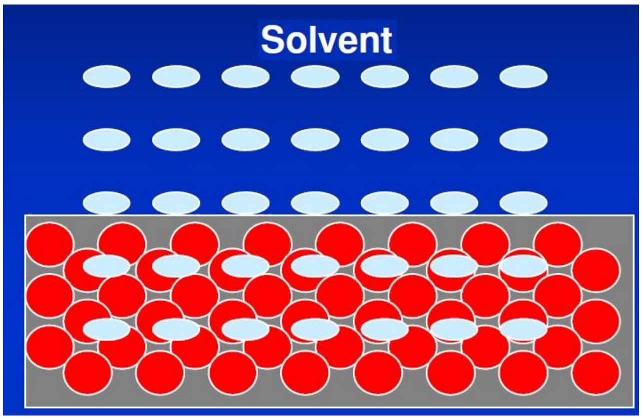


Figure 3.67 Solvent molecules in the paint film

Anticorrosive and anti-fouling paints are typically used on ships' hulls and are the main two types of paint used in the shipbuilding industry. The anticorrosive paints are either vinyl-, lacquer-, urethane- or newer epoxy-based coating systems. The epoxy systems are now very popular and exhibit all of the qualities which the marine environment requires. Anti-fouling paints are used to prevent the growth and attachment of marine organisms on the hulls of vessels. Copper-based paints are widely used as anti-fouling paints. These paints release minute quantities of toxic substances in the immediate vicinity of the vessel's hull. To achieve different colours, lampblack, red iron oxide or titanium dioxide may be added to the paint.

3.6.12.2. Pre painting process

3.6.12.2.1. Client requirements

Paint types vary from water-based coatings to high-performance epoxy coatings.

The type of paint required for a certain location depends on the environment to which the coating will be exposed. No one paint can perform all of the desired functions rust prevention, anti-fouling and alkaline resistance, therefore, many different painting systems exist to undertake protection for each locations.

The clients have right to select paint system depending on function of the ship with consulting from painting manufactures. The selection of paint system relates to some criteria, including environmental conditions, severity of environmental exposure, drying and curing times, applications equipment and procedures.

Table 3.11 Locations on ship to be painted

Critical areas in ship painting	Main requirements	Typical paint systems
Sides and superstructures	Appearance, anticorrosive protection, washability, UV resistance	Pure or modified epoxy primer/epoxy topcoat Aliphatic polyurethane/acrylic Polysiloxane/epoxy hybrid (anti-rust stain topcoat may be applied)
Decks	Appearance, anticorrosive protection, washability, UV resistance, mom-slip	Zic silicate followed by two-pack epoxy/polyurethane system Trowel-or roller-applied elastomer (1-3mm) over high build primer Topcoat should include aggregate, aluminium oxide, silica or others to provide non-slip properties
Tanks Ballast	Resistance to alternating contract with sea water and with transported products	Modified epoxy Aluminium-pigmented pure epoxy Solvent-free epoxy Special weaterborne asphaltic emulsion Cement-reinforce acrylic
Cargo Crude or petroleum Oils or hydrocarbons Very aggressive products	Resistance to contact with specific cargo types	High-solid or solvent-free polyamine-cured epoxy High-solid polyamine epoxy Epoxy-cyclosilicone

Painting Specification is produced to support shipyard from painting manufacturer with the agreement of ship owner. In this document, all parameters are mentioned to make the quality of paint as good as possible. In each step of process the witness and approval of supervisor from painting manufacturer is necessary. The supervisor is responsible for checking temperature and humidity and surface preparation after that the decision of next painting is made due to real situation.

Figure 3.68 Checking surface preparision by supervisor from paint manufacture

The ship must be applied adequate standard of specific country and international regulation. There are common to follow International Standard ISO/FDIS 12944:1997(E) or International Standard ISO 8504:2000

3.6.12.2.2. Painting cost estimation

The painting department is responsible for procurement of paint so that amount of paint needed have to be calculated.

From general arrangement and structure drawings, painting areas are calculated from total area of plates and profiles. The thickness of paint and type of paint are also considered to achieve final weight of coating. To evaluate the total price of painting, wasted factor and labour cost are included. The shipyard working closely with painting manufactures to guarantee quality of coating.

As same as construction process, painting process needs to have clear schedule to plan workforce and equipments properly in order to have the best quality and productivity.

3.6.12.3. Painting process

3.6.12.3.1. Surface preparation

The surface preparation is of paramount importance in the performance of a coating. A good paint may show failure when applied on a poorly prepared surface. Experience has shown that nearly 80-90 % paint failures can be traced back to insufficient surface preparation. The main objectives of surface preparation are to remove the surface contaminants, which are detrimental to the paint and to create a proper anchor pattern profile that facilitates the adhesion of the coating to the substrate. Mill scale, rust, salts, oil / grease, dust and loosely adhered old paint are major surface contaminants. These are removed by various methods such as abrasive blasting, compressed air / vacuum cleaning, degreasing, manual and power tool cleaning.

Table 3.12 Surface preparation methods

No	Containment	Effect on Paint Coating	Method of Removal
1	Rust	Weak to support paint coating being porous, tends to attract moisture and salts	Blast cleaning or mechanical cleaning
2	Oil/Grease	Interferes, in adhesion between surface and coating	Degreasing
3	Salts	Osmotic blistering, adhesion failure, corrosion	Fresh water cleaning
4	Dust	Paint adheres well to dust, but results in detachment of dust alongwith paint from the substrate	Compressed air/vacuum
5	Old Paint	Lack of adhesion/cohesion compatibility, if to be coated with another type. Adds to unevenness of the painted surface	Blast cleaning, mechanical cleaning, use of paint removers

Grades of Surface Preparation

Each preparation grade is designated by appropriate letters “Sa”. “St”, “Fl” or “Wa” to indicate the type of cleaning method used.

- Sa - indicates blast cleaning
- St- indicates hand and power tool cleaning
- Fl - indicates flame cleaning
- Wa - indicates water jetting

Table 3.13 Initial condition of steel

Rust grade	Pictorial example	Description
A		Steel covered completely with adherent mill scale and with, if any, little rust.
B		Steel surface which has begun to rust and from which the mill scale has begun to flake.
C		Steel surface on which the mill scale has rusted away or from which it can be scrapped, but with little pitting visible to the naked eye.
D		Steel surface on which the mill scale has rusted away and on which considerable pitting is visible to the naked eye.

The most effective cleaning method and widely use is blast cleaning so that great attention is given for this procedure.

Blast cleaning standards uses metallic or non-metallic (mineral) grits/shots for surface cleaning. The use of steel grit on surfaces other than steel or cast iron should be avoided. Vacuum blasting is a closed circuit process in which the grit is reclaimed and reused immediately after the dust and debris is removed. Following are the various shot blast standards:

- Sa 1 - Light Blast Cleaning When Viewed without Magnification the surface shall be free from visible oil, grease and dirt and from poorly adhering mill scale, rust, paint coatings and foreign matter.
- Sa 2 - Thorough Blast Cleaning When viewed without magnification, the surface shall be free from visible oil, grease and dirt and from most of the mill scale, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering.
- Sa 2½ – Very Thorough Blast Cleaning When viewed without magnification, the surface shall be free from visible oil, grease and dirt and from mill scale, rust, paint coatings and foreign matter. Finally the surface is cleaned with a vacuum cleaner,

clean dry compressed air or a clean brush. Any remaining traces of contamination shall show only as slight stains in the form of spots or stripes.

- Sa 3 –Visually Clean Steel When viewed without magnification, the surface shall be free from visible oil, grease and dirt and from mill scale, rust, paint coatings and foreign matter. It shall have a uniform metallic colour.

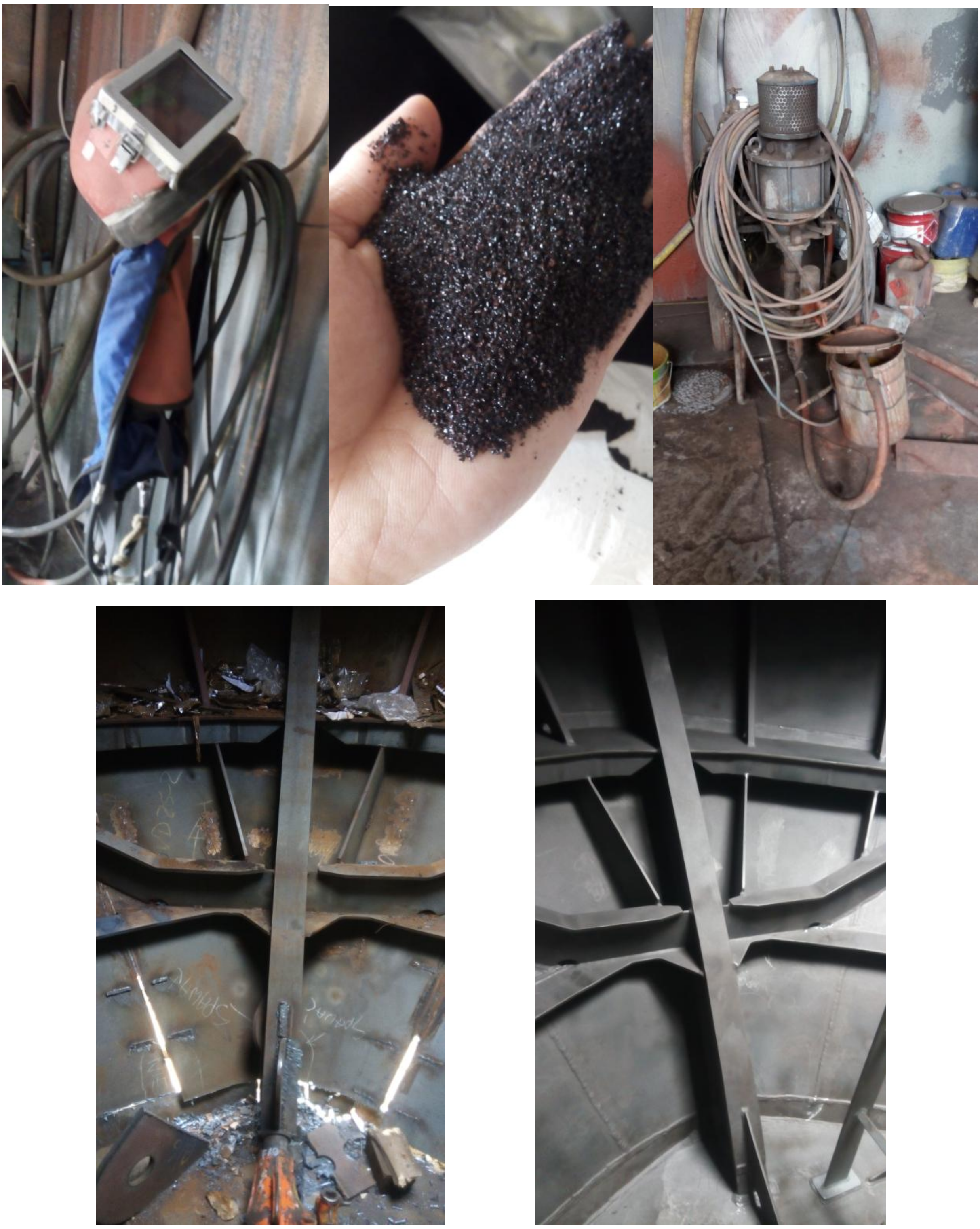


Figure 3.69 Blast cleaning equipments and result

Table 3.14 Cleaning surfaces standard

Cleaning standard	Initial steel condition (see also table 1).			
	A	B	C	D
St2 – Hand tool cleaning	Not applicable			
St3 - Power tool cleaning	Not applicable			
Sa1 -Brush-off blast	Not applicable			
Sa2 - Commercial blast	Not applicable			
Sa2.5 -Near white metal				
Sa3 - White metal				

3.6.12.3.2. Painting equipment

There are many types of paint application equipment used in the shipbuilding industry which ranges from simple brushes and rollers to airless sprayers and automatic machines. Two common methods used are compressed-air and airless sprayers.

Compressed-air systems spray both air and paint, which causes some paint to atomize (dry) quickly prior to reaching the intended surface. The transfer efficiency of air-assisted spray systems can vary from 65 to 80%. This low transfer efficiency is due mainly to overspray, drift and the air sprayer's inefficiencies; these sprayers are becoming obsolete because of their low transfer ability

The most widely used form of paint application in the shipbuilding industry is the airless sprayer. The airless sprayer is a system which simply compresses paint in a hydraulic line and has a spray nozzle at the end; hydrostatic pressure, instead of air pressure, conveys the paint. To reduce the amount of overspray and spillage, shipyards are maximizing the use of airless paint sprayers. Airless sprayers are much cleaner to operate and have fewer leaking problems than compressed-air sprayers because the system requires less pressure. Airless sprayers have close to 90% transfer efficiency, depending on the conditions. A new technology which can be added to the airless sprayer is called high volume, low pressure (HVLP). HVLP offers an even higher transfer efficiency, in certain conditions. Measurements of transfer efficiency are estimates and include allowances for drips and spills which can occur when painting. Reducing the amount of overspray also reduces the amount of paint used and thus saves the shipyard money.

Figure 3.70 Painting hull devices

Many shipyards have specific facilities and yard locations where painting takes place. Enclosed facilities or painting shops are expensive, but yield higher quality and efficiency. Open-air painting generally has a lower transfer efficiency and is limited to good weather conditions. Shrouding fences, made of steel, plastic or fabric, are frequently used to help contain paint overspray or to block the wind and catch paint particles. New technology will aid in reducing the amount of airborne particles.

Figure 3.71 Surronding plastic fence

The other common corrosion protection is done by sacrificial anode which modifies the corrosive environment:

Table 3.15 Characteristics of sacrificial anode

Advantages	Disadvantages
• No power supply needed • Simple to install • Simple to maintain • Current cannot be reversed	• Current depends on anode area • Cumbersome on large ships • Protection only when submerged • More expensive to maintain than a DC supply (ICCP) • Wiring for large anode arrays must be large enough to reduce resistance losses

Figure 3.72 Distribution of sacrificial anode on hull of ship

3.6.13. Out fitting

3.6.13.1. Subcontractors in the Shipyard

Subcontractors play important role because they conduct many of the functions the production workers and assist shops in the shipyard.

Subcontractors can perform painting, blasting, ventilation production and installation, piping system installation, electrical installation, and many others works.

Shipyards utilize subcontractors for their expertise in particular areas which require special knowledge or equipments and technical operators, in addition to even the manning load of the shipyard at times when there are load peaks that can reduces the need for shipyards to lay-off workers in times of reduced work-load

3.6.13.2. Support shops

Support shops contribute to overall success of project for shipyard. These are small manufacturers producing goods to support the production effort and the other support shops mainly provide services. Communications between the support shops and engineering determine efficient shipbuilding.

3.6.13.2.1. Pipe Shop

The pipe shop is responsible for manufacturing and assembling piping systems and it is noteworthy that piping systems are the largest outfitting task in shipbuilding.

The fundamental of pipe sections is "pipe spools" which are assembled in the pipe shop and transported to the many stages of construction, for instance fabrication, on-block, on-unit, and on-boad.

Some of the processes in the pipe shop are : pipe welding (arc, MIG, TIG, pulse arc), pipe bending, flux removal, grit-blast, pickling, painting, galvanizing, and pressure testing.

Some of the equipment used by the pipe shop are as follows: pipe welders, lathes, pipe cutting saws, shears, grinders, chippers, hole cutters, pipe benders, pickling tanks, transportation equipment.

Figure 3.73 Pipe element types

3.6.13.2.2. Plate Shop

The plate shop provides steel parts cutting, bending, and sub-assembly.

The plate shop uses information from engineering drawings to produce plate shapes by cutting and forming to be needed configuration. The plate shop has manual and computer controlled machinery.

The types of machinery commonly found in the plate shop are cutting machines, steel bending machines and plate bending rolls, shearing machines, presses, hole punching equipment, and furnaces for heat treatment. The plate shop sends the parts and sub-assemblies that they manufacture to the stages of construction.

DRILLING MACHINES

Some plates or sections may contain bolted covers and portable plates so that they need to have holes drilled. Drilling machines generally include of a single drilling head mounted on a radial arm which traverses the drill bed. [10]

Figure 3.74 Drilling machines

GUILLOTINES

Smaller 'one-off' plate shapes such as beam knees, various brackets and flat bar lengths may be cut in a hydraulically operated guillotine. Plate feed to the guillotine is usually assisted by the mean of plate supporting roller castors, and positioning of the cut edge is by hand. [10]

Figure 3.75 Guillotines

PRESSES MACHINE

Hydraulic presses can be usually used in the shipyard for a variety of purposes such as bending, straightening, flanging, dishing, and swaging plates.

All of the work may be done with the cold plate, and it is possible to carry out most of the work undertaken by a set of rolls. This method is low initial investment cost but it is slower when used for bending and requires greater skill. [10]

Figure 3.76 Hydraulic presses to bend brackets

3.6.14. Launching

Once the hull is structurally complete and watertight after carefully checked and tested, the vessel is ready to be launched.

Figure 3.77 Leakage test for holes

Launching consists of several methods involving sliding it into the water from the slipway on which ship was constructed, flooding of the dock or lowering the vessel into the water. Owing to medium size of ship, shipyard takes the advantages of gantry and mobility or even floating crane to lower the ship to the sea.

Table 3.16 Launching by crane

Advantages	Disadvantages
- Release the water level completely - Unspecified localization of the boat on the ground - Require only tracks - Tracks or pneumatics - Operational safety	- Limited to the small units - Maintenance of the various machine parts

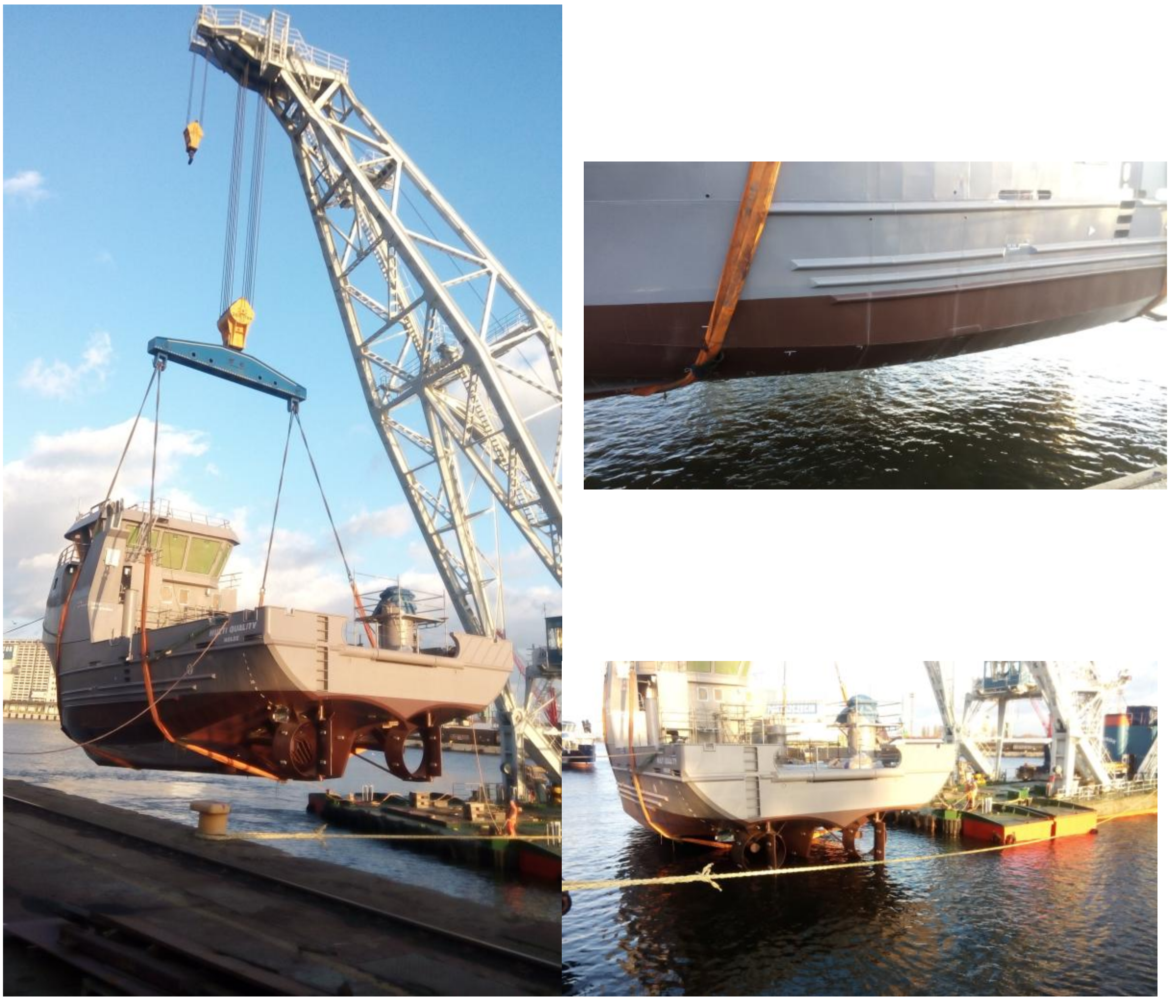


Figure 3.78 Launching by crane

The great considerations are the stability of ship and floating crane during lunching and incomplete ship hull at quay so that stability calculation must be perform.

Another problem is lifting lugs that should have adequate strength to support the hull structure weight and not contain large deformation near lifting brackets. The Finite Element Analysis are mandatory to ensure the design lifting lugs fulfil its mission.

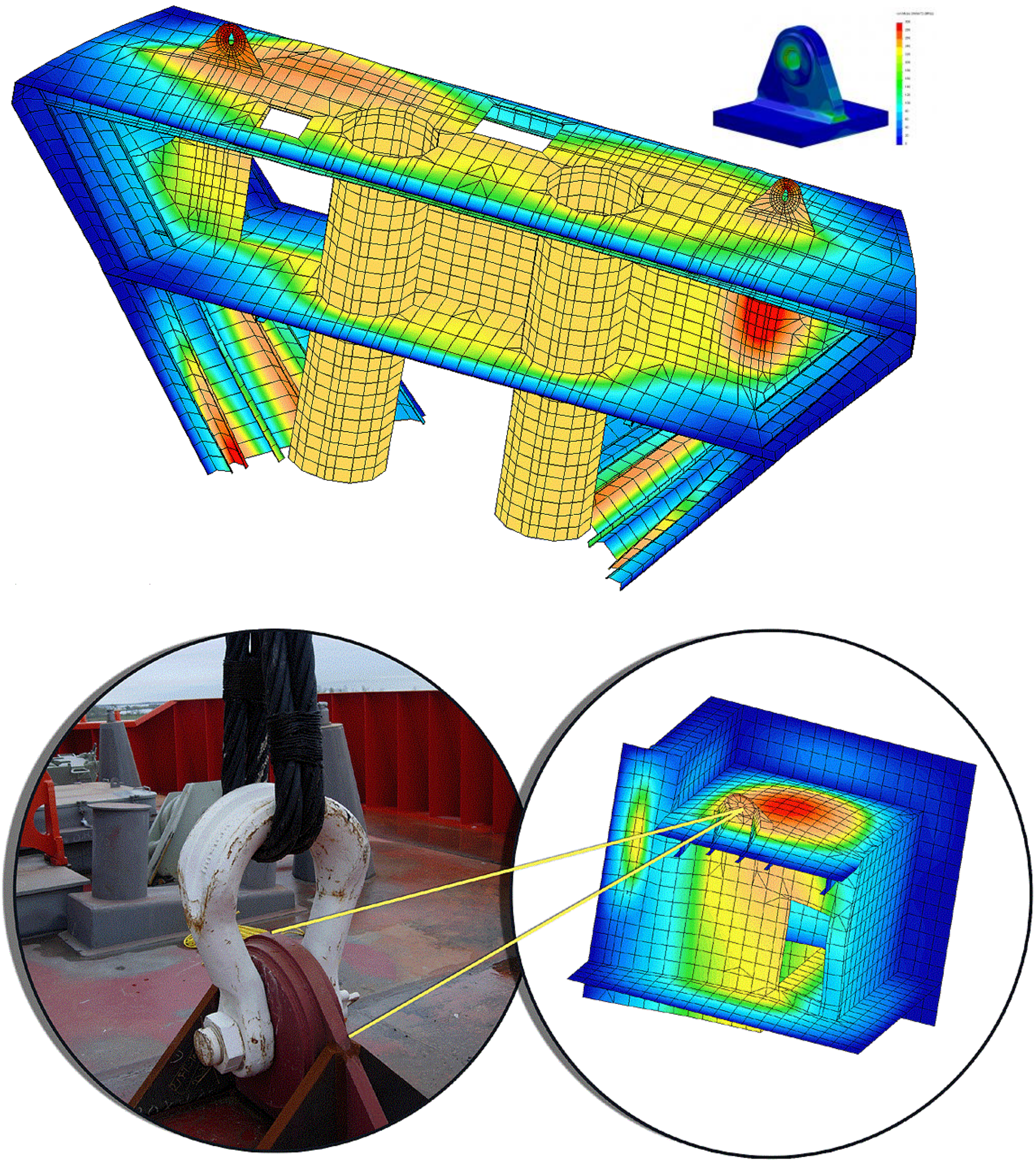


Figure 3.79 FEM analysis for lifting lugs

Alternative launching is transversal slipway collaborated with hydraulic systems and pontoon.

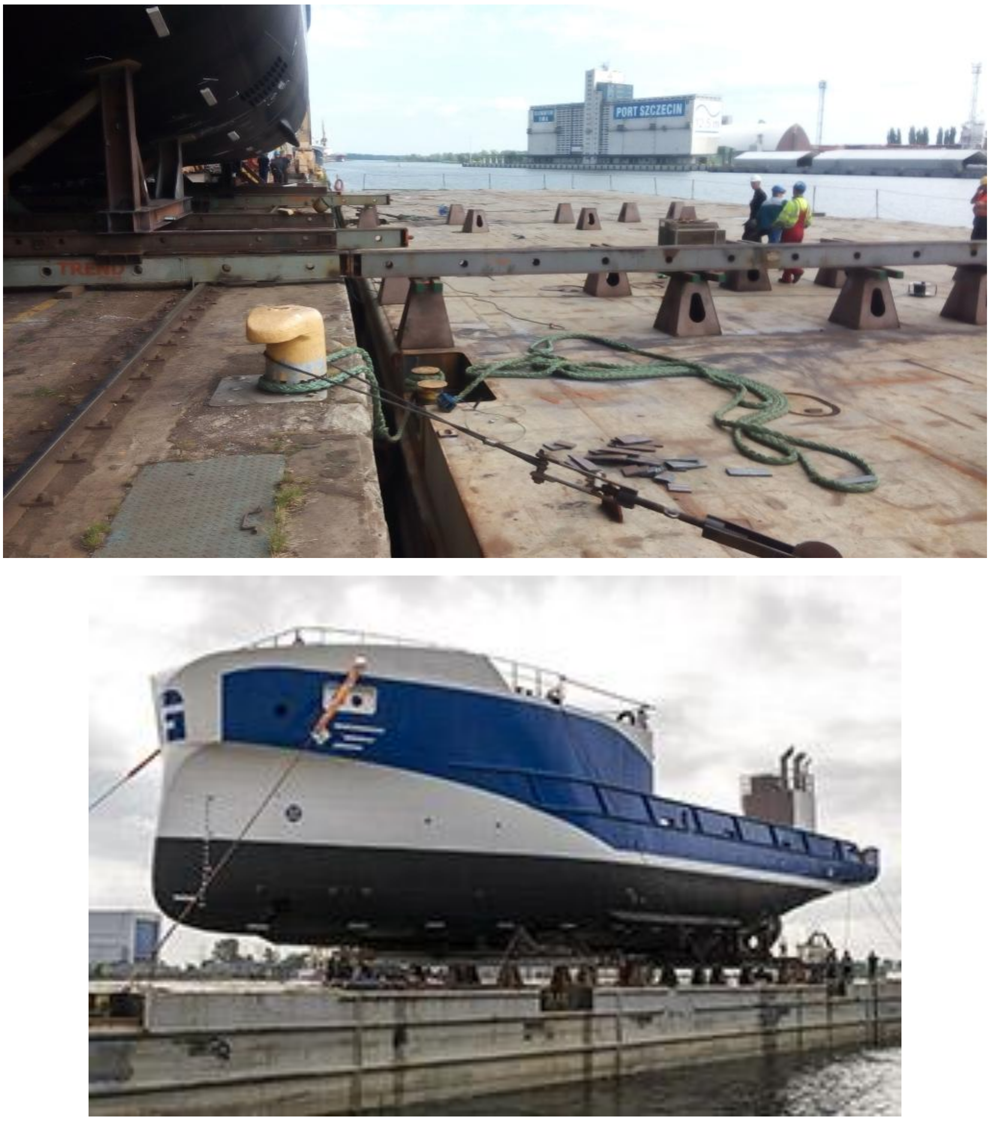


Figure 3.80 Process of launching ship by pontoon and hydraulic pistons

After launching a ship, the outfitting phase at quay takes place. A large amount of time and equipment are required. These works are the fitting of cabling and piping, the furnishing of galleys and accommodations, insulation work, installation of electronic equipment and navigation aids and installation of propulsion and ancillary machinery.

After finishing construction, the ship goes to sea trials, during which all the ship's systems are proved to be fully functional and operational under the witness of shipbuilder, ship owner and classification society sometimes authority of the country. Finally, after all testing and associated repair work is performed with the acceptance of the owner, and then the ship is delivered to the customer.

3.7. Products of FINOMAR shipyards

FINOMAR provide a wide range of offshore structures designated for operation in the extreme sea conditions. There are 4 main production fields that are constructed in company:

- Offshore structure
- Shipbuilding
- Power industry
- Others

3.7.1. Offshore structure

- SKIDs – pipe supporting structures,
- VOCs – specialist structures for recovery of gas installed in tankers,
- Burner Booms – masts for torch for the drilling rigs together with pipe installation,
- Steel anchors - for floating platform.

- SKIDs:

Skids are the structures used for supporting equipment forming part of the drilling rigs. They are solid, heavy, large-size, spatial structures, built of closed rectangular sections

Figure 3.81 FINOMAR product SKIDs

VOC Structures

VOC (Volatile Organic Compound Recovery & Return) system enable retaining and processing of the volatile organic products released during loading/unloading operations of the tankers what is demanded by the environmental protection.

Figure 3.82 FINOMAR product VOC

<u>Burner Booms</u>

Burner Booms are the supporting structures for a torch together with installations assembled on the drilling rigs.

Figure 3.83 FINOMAR product burner boom

3.7.2. Shipbuilding

The universal products for shipbuilding were made in company covering commercial and specialized ships

Figure 3.84 Service vessels

Figure 3.85 Fishing vessels

Figure 3.86 Tanker

Figure 3.87 Hopper barge

Figure 3.88 Pontoon

Figure 3.89 Lighter

Figure 3.90 Ferry

Figure 3.91 Icebreakers

3.7.3. Power industry

- Exhaust gas dampers, louvers, exhaust gas ducts, casings for filters designated for exhaust gas desulfurization
- Distribution flaps designated for gas turbines exhaust (diverters)

Figure 3.92 Diverter

Figure 3.93 Foundations for towers for wind power plants

3.7.4. Other products

Bridge and crane structures, elements for road engineering, bodies for machinery and equipment.

Figure 3.94 Crushers

Figure 3.95 Anode cages

Figure 3.96 Multi-purpose tanks

3.8. Differences in Practical work

3.8.1. Bad design

In some cases, shipyard received poor designs due to lack of experience or misunderstanding the feasibility of construction work. This creates difficulties for production process to achieve the goal that design aim at. If it is impossible to construct accordance with design , the modifications will be needed to make it possible. Any changes in design resulting from poor design are subjected to punishments.

Figure 3.97 Poor junctions between stiffeners

In this case, longitudinal and transverse stiffeners are just weld together only on the web otherwise the flange of stiffeners, the main part support to overall strength of structure are free. This phenomenon can damage for the stiffness of panel and whole hull structure.

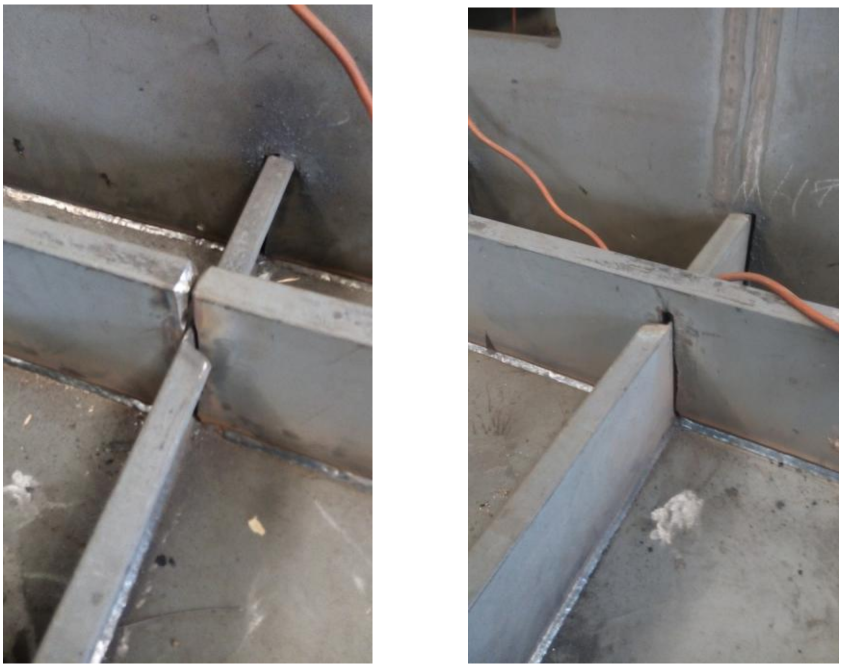


Figure 3.98 Poor junctions between stiffeners and girders

The discontinuity of the web frame makes it difficult to weld as first picture
And if it follows the principle as second picture, it requires a amount of time to cut flag of stiffener and web of web frame as well as difficult to fit together by small gap.

Figure 3.99 Not achieving proper curvature of steel plate

The curvature of the steel plate at bow is too sophisticated that bending plate cannot give correct shape to joint with support structure. Excess compression efforts and thermal solutions, therefore, are applied to fit the plate to structure which may introduce much residual stress inside.

3.8.2. Improvement for shipyard

3.8.2.1. Investment for machinery

Lifting by clamp may create high deformation at the contact spot and as result, the straightening have been carried out after that. This consequence consumes time and costly. The solution to improve the handling facilities can be done by a device known as a 'captivator'. Plates required for the work may be pre-stacked at the captivator which can be remotely controlled so that as each plate is required it lifts, using magnetic clamps, the plate from the top of the pile and then transfers it to a carriage. A shipyard employing this technique can in fact become highly automated

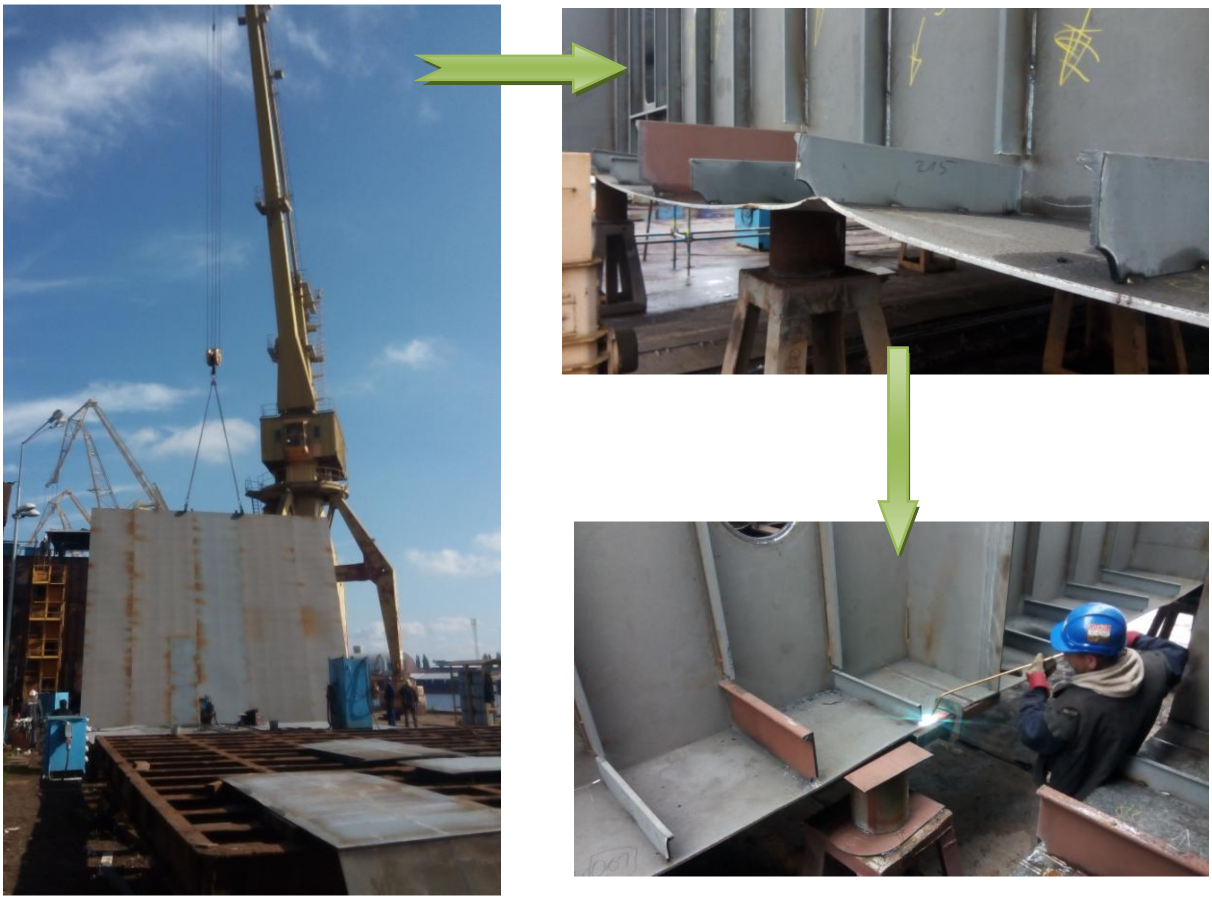


Figure 3.100 Distortion edges of plate due to lifting

The plasma cutting in FINOMAR shipyard is air plasma with one torch so that it makes noise and smoke, in addition, the working time of this machine is limited by cooling system. There are available now in market variety of modern cutting machines which perform 3D dimension with multiple torch and wide range of function such as cutting, chamfering and marking in long time operating. It is worth to invest new machine that can help increase productivity.

3.8.2.2. Planning schedule

The toughest mission is planning for project. Each project is different to the others because of their complexity and no previous experience due to one-type-product. The task is how to balance workforce and work load at every time. This contains lots of uncertainties that manager cannot control, for example changing of weather, accident, new project coming and many others. In previous time, the schedule are produced base on long time experience of senior staffs who observer many process and can evaluate approximately time and cost. But now with the high demand and short time process as well as new shipbuilding technology these experiences cannot guarantee successful planning.

Thank to rapid development of simulation, the event now can simulate in real time which can predict exactly amount of work and time required. The optimization now can find the best solution for existing facility of shipyard as well as allows operators change parameters during construction time owing to new constraints coming.

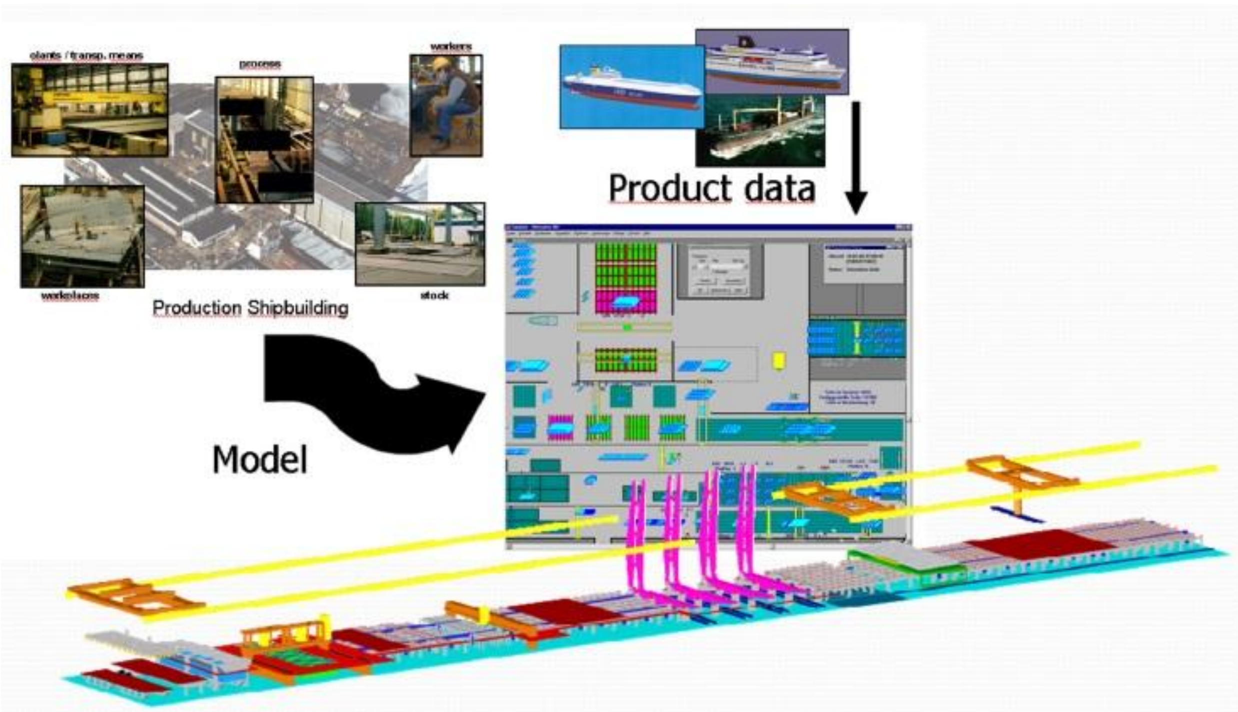
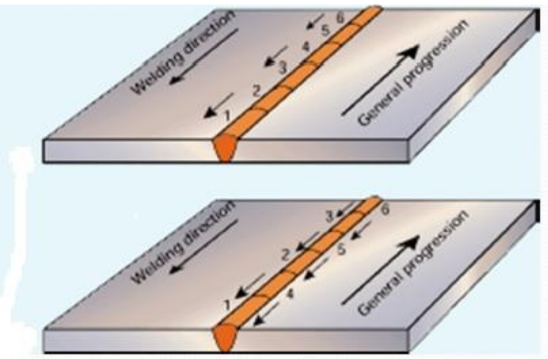


Figure 3.101 Production simulation

3.8.2.3. Reduce distortion

A large amount of work is given to straightening resulting of distortion.

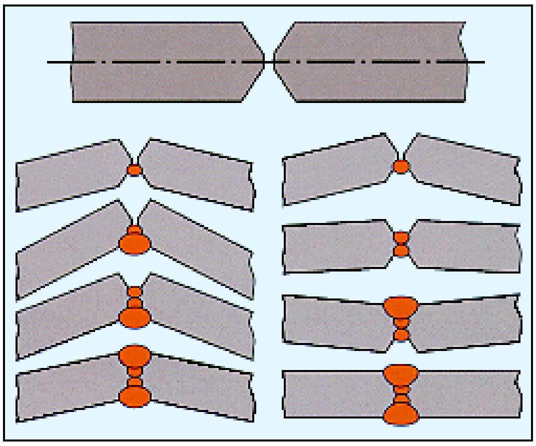
Solution to minimise distortion can appear every step of construction form fabrication shop, assembly units to erection.



In manual welding the ‘back step’ and ‘wandering’ methods of welding are often recommended, the length of each step being the amount of weld metal laid down by an electrode to suit the required cross section of weld. This, however, may reduce efficiency of welding process.

Figure 3.102 Back step welding

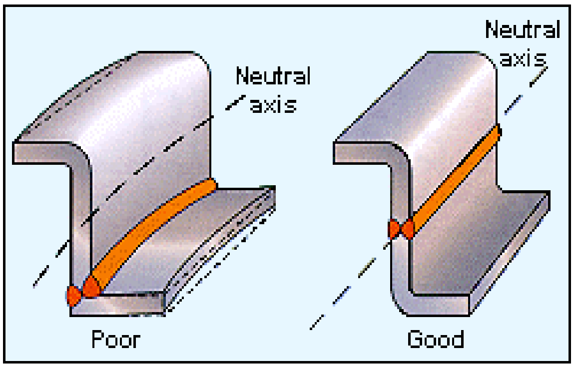
Distortion could often be prevented at the design stage, for example, by locating the welds about the neutral axis, reducing the amount of welding and depositing the weld metal using a balanced welding technique.



Balanced welding is an effective method to control angular distortion in a multi-pass butt weld by arranging the welding sequence to ensure that angular distortion is continually being corrected and not allowed to accumulate during welding.

Figure 3.103 Balanced welding method

The closer a weld is positioned to the neutral axis of a fabrication, the lower the leverage effect of the shrinkage forces and the final distortion.



In practical, most welds are far away from the neutral axis, distortion can be minimised by designing the fabrication so the shrinkage forces of an individual weld are balanced by placing another weld on the opposite side of the neutral axis.

Figure 3.104 Arrangement of welding line

These steel pieces are pre-set and left free to move during welding. In practice, the parts are pre-set by a pre-determined amount so that distortion occurring during welding is used to achieve overall alignment and dimensional control. The main advantage is no expensive equipment needed and there will be lower residual stress in the structure.

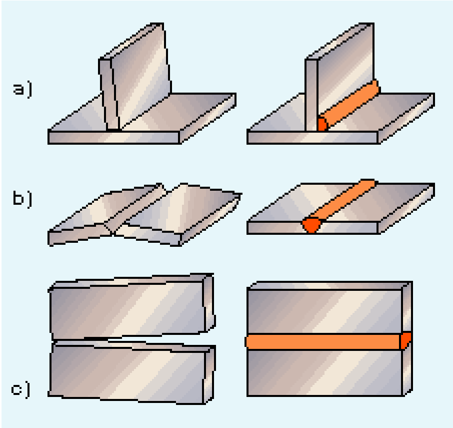


Figure 3.105 Pre-set to move at joint

However, as it is difficult to predict the amount of pre-setting needed to accommodate shrinkage, a number of trial welds will be required. Pre-setting is a technique more suitable for simple components or assemblies.

Pre-bending, or pre-springing the parts before welding is a technique used to pre-stress the assembly to counteract shrinkage during welding. Pre-bending by means of strongbacks and wedges can be used to pre-set a seam before welding to compensate for angular distortion. Releasing the wedges after welding will allow the parts to move back into alignment.

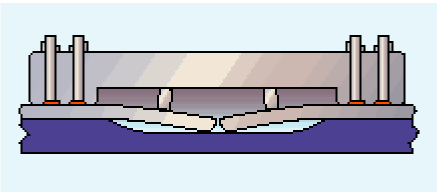


Figure 3.106 Pre-bending for groove weld

The influences the degree of distortion is mainly defined by its effect on the heat input form weld. The developments in low heat input transfer modes for MIG/MAG are now available It can be reminded that there are three principal metal transfer modes:

- Short circuiting/ dip
- Droplet / spray
- Pulsed

Dip transfer combines low current or heat input and a small wire diameter with repeated short-circuiting between the wire and the weld pool, making the process suitable for joining thin sheet and positional welding. Recent developments in equipment, associated with advances in inverter technology and electronic control have resulted in greater refinements to the process, including improvements in the control and stability of short circuiting or dip transfer.

There have been a large number of developments by welding equipment manufacturers to improve process stability and reduce spatter, giving a large choice of potential systems that fabricators can adopt. [9]

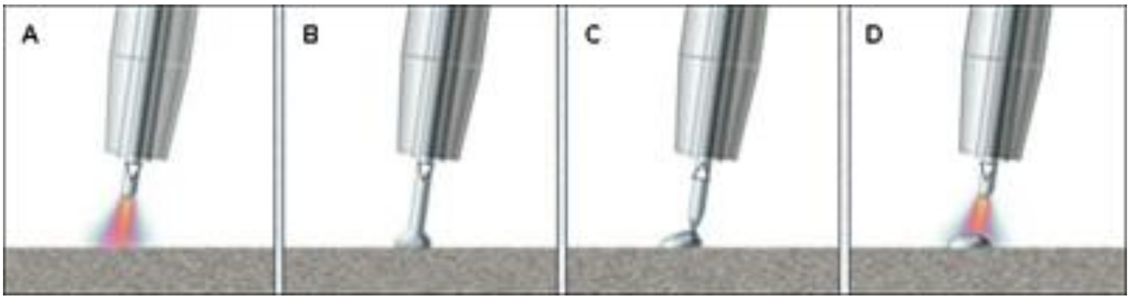


Figure 3.107 Principal phases of wire feed control

4. CONCLUSIONS

4.1. Concluding remarks

In this thesis, issues related to condition for offshore construction were analyzed. These include a review of constraints for shipbuilding in both economic and technical aspects presented in section 2. By providing the clear challenges and specific competitors, European shipyards have to find the way to adapt new market with changing form leading position to be more equally players around the world.

In addition, a comprehensive approach with appropriate interpretation about the sources of problems describes overall picture of shipbuilding industry then the solution are discussed in order to address the drawbacks causing mainly by high price of labour.

With respect to the production process, the evaluations performed in section 3 indicate that medium-sized companies are able to survive in critical period by utilizing their dynamic in many fields of products that enhances more competitiveness and also more opportunity to expand the range of possible construction can be built. By following production line from beginning to the end, the assessment of affected factors to construction are given by providing the advantages and its disadvantages of individual stage from which improvements may be found out.

Great consideration was made to natural geographical feature which modifies the production flow and organization of workshops and machinery as well as environment condition was noted for scheduling during a year. The next essential contribution factor of shipyard is workforce that is key success to determine the strength of company. High qualified employees guarantee the outstanding quality for products and then bring back greater profit. However, lack of skilled workers and aging problems are coming as challenges which induce shipyard to promote timely measures. Shipyard facility plays an important role in production process and investigating how it affects to productivity is carefully analyzed. The building process is mainly related to steel element so that methods to shape and treatment for this primary component are evaluated. Cutting, bending and welding as well as many supported process were described with evaluation of how its suitability for this type of shipyard.

Furthermore, many impossible or costly constructions during production with the lack of consideration for practical work from designers occur and solutions for these mistakes were mentioned.

Finally, the wide range of products built in this shipyard was performed to prove their capacity and also possibility for further work even more complex with competitive price.

4.2. Recommendations for further work

The thesis was made according to qualitative method so that it created the route for understanding process in existing medium-sized company. Assessment of various factors is beneficial for evaluation of the extent level for contributing aspects.

Future work based on this thesis result would be conducted by quantitative method to obtain more data for single factor and then the improvement can be launched to take full potential advantage.

It would also be profitable to acquire a comparison of results from same product in big enterprise and medium one to investigate for certain process which is the better solution and then modifying may be necessary to minimize wasted sources

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